THE ILLUMINATING ENGINEER

LIGHT LAMPS FITTINGS AND ILLUMINATION

THE JOURNAL OF

GOOD LIGHTING

Official Organ of the Illuminating Engineering Society

FOUNDED IN LONDON 1908

Edited by LEON GASTER

. OIL . GAS ELECTRICITY ACETYLENE PETROL-AIR GAS ETC.

Vol. XVIII | April, 1925 | Price NINEPENCE
Subscription 10/6 per annum, post free
For Foreign Countries, 15/- per annum.

Special Features:

Recommendations on the Lighting of Buildings and Streets—Notes for the Photometric Laboratory—The Effect of Light on the Human Body—Artificial Daylight—The Illumination of Post Offices—The Lighting of the Home—Further Examples of Flood Lighting—News from Abroad, etc.

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EDITORIAL AND PUBLISHING OFFICES:
32 VICTORIA STREET, LONDON, S.W. 1.
Tel. No.: Victoria 5215

News on Illuminating Engineering from Abroad

IN stating our aims and objects in the January issue of this journal, the first issued in the revised and extended form, we mentioned our intention of making special arrangements for the receipt of news from abroad, through the medium of correspondents in most of the chief cities of Europe and the United States. The organization of the necessary machinery and the resumption of old relations is proceeding rapidly. We have already got in touch with a number of our correspondents, and on pp. 91-92 we reproduce (or translate) letters which we have already received from many eminent experts on illumination. The response to our invitation to contribute has been gratifying, and we are glad to note that the views received from abroad agree with those expressed at home, in expressing appreciation of the journal in its extended form.

The friendly relations existing between the Illuminating Engineering Societies in this country and the United States are exemplified by the mutual arrangement, now officially arranged, for the interchange of papers. It will be a great advantage to lighting experts in both countries to hear what is taking place "across the water," and we hope that it will be possible to arrange for specially important papers to be read and discussed before both societies. We propose to arrange a similar exchange of contributions with bodies in other countries.

In our present issue we are already presenting a considerable amount of information from abroad. The recommendations for the lighting of buildings and streets, recently framed by the German Illuminating Engineering Society (pp. 96-97) are of interest, as in the main confirming recent proposals in this country. The tests recently described before the same body on the effect of higher illuminations on various processes involving acuteness of vision, sustained attention, manual dexterity, etc. (pp. 99-100) deserve attention as a scientific method of studying the effect of lighting on industrial processes. In this connection the very comprehensive report recently issued by the United States Public Health Service on "The Lighting of Post Offices" (pp. 98-99) is of special value.

Other shorter contributions deal with such matters as new forms of lamps, lighting for aerial navigation and varied subjects. We take this opportunity of again inviting the aid of all our readers, at home and abroad. We are anxious to receive interesting news and information of all descriptions, and to make the journal a connecting link between different countries so that all data bearing on the provision of better illumination in the service of mankind may be disseminated as widely as possible.

The E.D.A. and Illumination

THE dominant note in the speeches delivered at the annual general meeting of the British Electrical Development Association on April 17th was the need for extensive educational publicity. Mr. Frank Gill (past President of the Institute of Electrical Engineers), in proposing the toast of the Association, paid a tribute to the good work being done by the Association under Mr. Beauchamp's direction. He urged that more publicity was needed, and he made one very important suggestion—that the scope of work might be considerably extended if the general public were represented on the E.D.A. organization. Other speakers endorsed the importance of propaganda in the lighting field. Mr. S. T. Allen, in proposing "The Guests," referred to the wide ramifications of its work, likewise emphasized this point, and Mr. S. E. Doane (of the International General Electric Co., New York), in responding, expressed his pleasure at the evidences of activity in the form of demonstrations, which had for some years been a feature in the United States but only recently developed in this country.

Whilst we may concede that the electrical industry has only lately become awakened to the importance of educating the public to appreciate the benefits of better lighting, it should not be forgotten that the Illuminating Engineering Society and its journal have been doing their utmost to draw attention to all aspects of the subject for about seventeen years. Their pioneering work has paved the way for the efforts of the gas and electrical industries in this field. It should be noted also that the Society has, from the very start, recognized the necessity of enlisting the help of those associated with all aspects of illumination, including the users—the general public. To us, therefore, the gospel of co-operation, endorsed at this gathering, is familiar. The extension of the movement for better lighting should be based on co-ordination of the activities of the Society with those of all other bodies, whether gas or electric, or representing some section of the public. We welcome the growing recognition of the important function that the Society can fulfil as a "liaison officer," linking all these efforts in a common campaign.

A well-merited tribute was also paid to the part played by the press in giving publicity to illumination. Our own journal is specially devoted to this work, but we have taken every opportunity of acknowledging the good services of the daily and technical press in making the claims of good lighting known to a wider circle. Here again our motto must be co-operation. Such services are gladly rendered, but they should be recognized by suitable support from the lighting industry, which benefits by the movement in favour of better illumination.

Street Accidents and the "Safety First" Movement

THE address delivered by the Chairman (Alderman J. J. Bisgood, J.P.) at the annual meeting of the London Safety First Council on April 17th shows the seriousness of the problem of street safety. The Home Office official returns for street accidents caused by vehicles during 1924 indicate a total of 98,215 accidents, of which London was responsible for 61,344 and the rest of the country for 36,871. The metropolis, as might be expected, is especially liable to street accidents; for the volume of traffic is far larger and the number of journeys per head of population much greater than in provincial cities. Hence the average for London works out at one accident per 200 persons, whereas for the country as a whole it is one per 450.

Nevertheless, when we examine figures for successive years it is possible to trace the effect of the Council's safety first propaganda. The increase in accidents in London, as compared with 1923, was 16 per cent.; the corresponding increase for the rest of the country 20 per cent. Had the rate of increase been the same as in the provinces there would have been 12,000 more casualties in London last year. This may be taken as a fair measure of the value of the work of the London Safety First Council to the community.

Further information is available from the tables of annual numbers of accidents during the period 1918 to 1924. In the provinces the increase in the number of accidents during this period was 200 per cent., in London 127 per cent. Here again the difference in the increases for London and the rest of the country (which is consistent year by year) bears evidence of the educational value of the Council's work. But the melancholy fact is that, even in London, the number of accidents tends to increase steadily year by year. This is a natural outcome of the vast increase in the volume of motor traffic, but it is imperative to check it in some way. Educational measures have a valuable effect, and the work of the Council in this direction should receive every encouragement, and should be extended, under the auspices of the National Safety First Association, into the provinces.

But the problem is so vast and important as to justify investigation from another aspect—the analysis of the main causes of this vast increase in casualties. We recall that Mr. H. E. Blain, some time ago, suggested that the time was ripe for a measure requiring every fatal street accident to be the subject of official enquiry, as is already prescribed for accidents on railways. If, in addition, fuller details of material facts could be recorded when each accident occurred, we should be able to trace more completely the causes of accidents and to suggest remedies.

As we have repeatedly pointed out, the manner in which returns are presented makes it difficult to trace with precision the proportion of accidents occurring at night. But so far as they go the figures for "night" and "day" accidents afford strong presumptive evidence that the proportion of accidents occurring at night is unduly great, considering that the average volume of traffic and number of persons in the street is so much less than in the daytime.

We sincerely hope, therefore, that the Council will press forward a demand for the detailed analysis of the causes of accidents, enabling us to trace this relation, and that they will continue to include in their programme the improvement of public street lighting. It is common knowledge that improvements in public lighting since the war have not kept pace with the continually increasing demands of traffic. Municipal and local authorities should recognize that it is their clear duty to do everything possible to improve the public lighting in their areas and thus remove one important contributory cause of street dangers—inadequate illumination.

It is also advisable that members of the public should be led to realize the vital importance to their safety of adequate lighting. On page 113 a reference is made to the admirable official journal of the National Safety First Association, in which information on safety methods is conveyed in a readable form. We should like to see similar methods applied to illumination so that the public may learn to appreciate the dangers of inefficient street lighting—for it is on the public demand that advances in street lighting ultimately depend.

Lectures on Illuminating Engineering at the Polytechnic

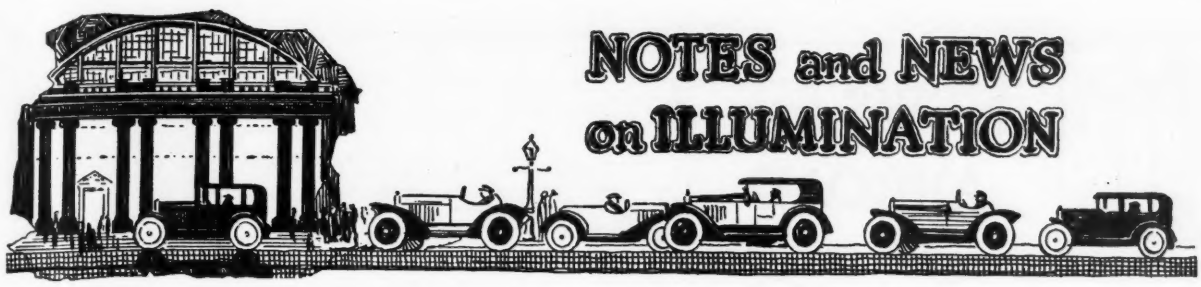
(Regent Street, London)

THE course of lectures on Illuminating Engineering, at the Polytechnic, Regent Street, announced in our last issue, was duly opened on April 20th, when Mr. J. W. T. Walsh delivered the first of the series on "The Nature of Light and its Measurement." In this number we give a brief abstract of this lecture, and likewise of the following one by Dr. James Kerr on "Light in Relation to Vision and Health." Both covered a wide field, and the two together formed a useful introduction to the remainder of the course. In our last issue we included a complete list of the lectures, and in the present number an announcement of the final series of six appears. (See p. iv.)

The two initial lectures are to be followed by the addresses by Mr. B. P. Dudding and Mr. J. G. Clark on advances in electric lamps and gas lighting respectively. Subsequently such problems as the lighting of the home, schools, offices, shops, factories, streets, railways, etc., will be dealt with. The course therefore covers a wide field, and should serve as a useful review of general progress in Illuminating Engineering. It is not often that students have an opportunity of attending such a complete series of lectures on varied aspects of lighting, each by an expert on the subject treated.

In referring to this course in our February issue we recalled that a somewhat similar series was arranged at this institution as far back as 1912. The information now available is very much greater than at that time, and the number of people interested in the subject has much increased. Firms concerned with lamps and lighting appliances and gas and electric supply undertakings should recognize the value of such lectures to their staffs, and we were glad to observe that at the opening lectures such concerns were well represented.

These lectures will, we hope, form the preliminary to an extension of education in Illuminating Engineering. At many institutions throughout the country there should be scope for similar work, and the course at the Polytechnic should furnish hints to many lecturers in regard to syllabus and method of treatment. Another step which we have in view, the preparation of a text book on illumination for the use of teachers and students, should likewise have the effect of stimulating interest in Iluminating Engineering. We hope shortly to be able to announce developments in this direction. Meantime it is of interest to observe the publication of a comprehensive work of this nature, edited by Messrs. F. E. Cady and H. B. Dates, and published in the United States, which will be reviewed in this journal shortly.



The Illuminating Engineering Society Some Forthcoming Events

During the present month the special course of lectures on Illuminating Engineering at the Polytechnic has been commenced, and as there are two lectures per week until the conclusion of the series at the end of May, these alone will provide abundant information for members. Several meetings and visits are in prospect, however, and the Society will wind up a busy session by exceptional activities in the months of May and June. Amongst other items there are papers in prospect dealing with natural and artificial light in health and disease (in co-operation with the Sunlight League), statistical data on shop lighting, and lighting conditions in mines; also a visit for the purpose of inspection of the gas lighting at Victoria Station and streets in the vicinity, followed by a discussion at the new showrooms of the Gas, Light & Coke Company. There are also other projected meetings and visits, particulars of those included during the present session will be announced shortly.

The Natural and Artificial Lighting of Buildings

The paper on the above subject, read before the Royal Institute of British Architects on April 20th by Mr. P. J. Waldram, dealt mainly with access of daylight into buildings, of which the author has made a special study. A brief account of some elementary principles in artificial lighting is also given, and the lecturer pointed out the differences in daylight and artificial light as usually applied, notably in regard to diffusion. We are glad that the subject is being brought before the notice of architects, whose co-operation in lighting matters is much to be desired. In buildings of architectural distinction especially, the concerted efforts of the architect and the lighting expert are needed; the former should consider the conditions of lighting which the characteristics of the building demand; the latter can then supply information of the latest developments in the lighting field, and show how artistic and practical requirements can best be reconciled and most efficiently met. We are very glad to observe the increased amount of attention being devoted to these matters by architects as illustrated by several papers read before architectural bodies during the past year. In particular we recall that a short time ago the question of show-window lighting was discussed—also a field where great opportunities for the services of architects exist.

Coloured Indication Lights for Motor Vehicles

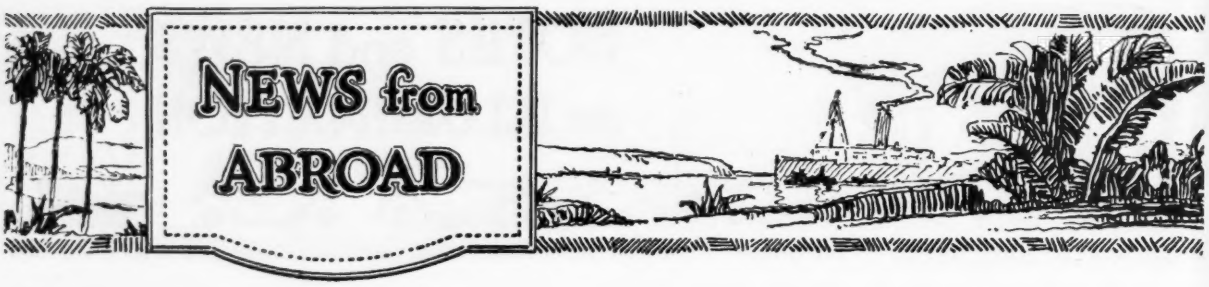
At the meeting of the London Safety First Council on April 17th a novel suggestion was put forward by the Street "Safety" Committee. One of the members proposed a system whereby every vehicle would carry a lamp screened by green glass on the off side and a similar lamp screened by red glass on the near side. By this means an "all right" or "stop" indication would be provided at night which would carry out the above rule of priority, and, if made compulsory, would obviate collisions at crossroads, which now constitute one of the chief forms of accidents. This idea, which has been commended to the Council for favourable consideration, certainly seems to deserve attention. No doubt some means of conveying an indication of the movements of vehicles at intersecting roads is needed. The method recalls the long-standing practice of ships at sea of having lights of different colours on the port and starboard. At this meeting various matters of interest in connection with lighting, notably the report of the Chairman (Alderman J. J. Bisgood) on Street Accident Statistics, to which reference is made on p. 88, were discussed. We may mention that Mr. L. Gaster, as the representative of the Illuminating Engineering Society, was re-elected as Chairman of the Publicity Committee and Vice-Chairman of the General Purposes Committee.

The Dimming of Headlights

The daily Press has been commenting pretty continuously on the question of motor headlights. The latest idea, vigorously pursued in some quarters, is to urge motorists *not* to switch off their headlights whilst meeting approaching vehicles. This, we believe, is at variance with practice on the Continent, where speeds are probably in excess of those in this country, but where the dimming of headlights when other vehicles are being passed is usual. The recent French legislation, as summarized recently by M. Bossu, contemplates two categories of projectors: very powerful headlights, liable to dazzle, which are not used on crowded roads but are suitable for unoccupied roads, and a less powerful form, which provides sufficient light to enable cars to be passed, and is substituted for the most powerful type when the latter is liable to confuse drivers of approaching vehicles. It is possible that a solution of the problem in this country may be found on these lines. It is practicable to contrive a headlight confining the beam below a certain height above the roadway and relatively free from dazzle. But many motorists consider that for safe driving at a high speed a certain amount of light must be allowed to pass upwards. Hence there would seem to be scope for a headlight, normally furnishing a confined beam, which could be manipulated by the driver so as to give additional power and upward direction of light when this can safely be used.

The Industrial Institute

As we go to press we note the announcement of the aims of the newly-formed Industrial Institute, outlined in a memorandum which has received a considerable amount of notice in the press. The Institute is entirely non-political, and has the support of an imposing list of eminent men and women, representing both capital and labour, science and industry. Its aims include the promotion of closer relations between science and industrial practice, the strengthening of the science of industrial ethics and the analysis of legislative and other proposals affecting industrial relations. All these are objects which command sympathy. We hope and believe that this influential body will include in its programme the study of industrial lighting—a field in which, as we have previously remarked, management and men can work in complete accord for their common interests.



A New German Enclosed Flame Arc

Although, in this country, arc lamps have been rather under a cloud during recent years, it is to be noted that they are apparently developing rapidly abroad. A correspondent sends us some notes on a new German enclosed flame arc which appears highly promising. Operating at 7·5 to 10 lamps, and using a single pair of carbons the lamp will work for 125 hours without recarboning, and in some recent tests as much as 140 hours' burning has been attained. Apparently the lamp works at something under 0·25 watts per candle (mean spherical) and its construction presents interesting features. Carbons furnishing white, yellow or red-orange light can be furnished, the latter being preferred in cities where fogs are frequent. We are informed that exhaustive tests of these lamps have recently been conducted by Herr Mylo, who is in charge of the public lighting in Berlin, and that a series of the lamps have been erected in the Bellevue Strasse (near the Potzdammerplatz) for comparative tests with 1,000 watt gasfilled incandescent lamps. The lamps are also on trial in Hamburg and other German cities, and are even being experimented with in cities as far distant as Cairo and Montreal. We hope in the near future to be able to give further details of these lamps, the development of which will be watched with interest. The most striking feature is the long burning period stated to be obtained with a single pair of carbons; this certainly would seem to mitigate the inherent disadvantage of the arc lamp of requiring periodical attention.

Lighting for Aerial Navigation

It will be recalled that in 1922 a valuable paper was read by Lieut.-Colonel Blandy, D.S.O., before a joint meeting of the Illuminating Engineering Society and the Royal Aeronautical Society, on "The Use of Light as an Aid to Aerial Navigation." Since that date little has been published on this subject, but we notice in *L'Elettrotecnica* a very comprehensive summary by Sig. Aristide Luria of developments in this field. The design of beacons and landing lights and projectors to be carried by aircraft is discussed in great detail. Possible illuminants are also reviewed very fully. Apparently high candle-power incandescent electric lamps yielding 3,000-4,000 and, in recent designs, even 8,000 candle-power, are proving very serviceable. Special interest attaches to the author's sketches of aerodrome searchlights, arranged at the corners of a rectangle or triangle, which furnish two beams, one sweeping the landing area and the other directed vertically upwards. The contribution is an interesting one to which we propose shortly to refer in detail.

Developments in Austria

The Austrian Illumir ating Engineering Society seems to be now actively at work. An address was recently given by Professor F. C. Caldwell (of Columbia University), who is on a visit to the country, reviewing the present position of illuminating engineering in the United States. On April 2nd Professor Dr. Teichmüller, Director of the Illuminating Engineering Institute in Karlsruhe, delivered an address entitled "A New Epoch in Illuminating Engineering." Another interesting incident was the opening in Vienna, on March 6th, of the electrical exhibition organized by the "Watt" Elektrische Gluhlampenfabrik. Herr Liebel, the director, in opening the proceedings, stated that this was the fourth European exhibition of this kind. An introductory address was delivered by Dr. E. M. Bausenwein, who referred to the continual advance in the amount of light used, which was fully justified on the grounds of health, safety and efficiency. In the school, home and factory better lighting is an essential to health, and is beneficial in other ways. (Dr. Bausenwein contended, for instance, that it is a foe to alcoholism—arguing that people in dismal and ill-lighted surroundings take refuge in drink, whereas those who live in comfortable, well-lighted buildings are raised to a higher level of self-respect.) He quoted investigations in support of the contention that better lighting leads to increases in productive power as high as 20-25 per cent., and pointed out that the cost of good lighting in the home forms only 0·5 to 1·5 per cent. of the total cost of maintenance and living. He likewise emphasized the commercial value of good lighting in stores, and pointed out that all sections of the electrical industry—not only makers of lamps but manufacturers of cables, switchgear, generators, meters, etc.—stand to gain by the movement for better lighting.

Lighting at the "Sports Palace" in Berlin

A German illustrated paper contains an effective picture of the artificial lighting of the large "Sports Palace" on the occasion of a vast public meeting. The speaker, Dr. Breitscheid, is seen silhouetted on the central rostrum surrounded by a sea of upturned faces. The illumination was afforded by overhead concentrating fittings, and the photograph was apparently taken entirely by artificial light.

The Economic Life of Electric Incandescent Lamps

It has sometimes been contended that consumers seek to obtain an unduly long life from electric incandescent lamps; and that generally speaking they would do well to be content with a shorter life and a higher efficiency. This, at least, is the conclusion of M. J. Wetzel, in a recent contribution to the *Revue Generale de l'Electricité*. The discussion of the subject is mathematical. It is not in the true interests of consumers to do as some do—under-run their lamps slightly in order to obtain long life. Indeed M. Wetzel contends that lamps as at present manufactured might frequently be slightly over-run with advantage. One point the author strongly insists upon, however, the importance of constancy of voltage. Consumers are inconvenienced even by a voltage fluctuation of 2 per cent., up or down. In the case of large stores, factories, etc., it would, he thinks, pay to install a special voltage-regulator, ensuring constancy within narrow limits.

The Properties of Neon Lamps

A certain amount of information has been acquired about the new neon ("Osglim") lamps. Pearson and Anson in this country have shown that the resistance of the lamp is negative, i.e., increases with decreasing current, and that there is a critical voltage below which the lamp does not glow. Mr. B. N. Ghose, in the *Physical Review*, mentions some other properties. He finds that the intensity of the light is approximately proportional to the current and that over a wide range the product CR (C denoting current and R resistance) is constant. Another interesting point is that the lamp can be conveniently used to measure high resistances of the order of a few megohms.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Some Letters of Appreciation from Corresponding Members Abroad

(In the following pages we are reproducing a few of the replies received in response to our invitation to lighting experts abroad to co-operate with this Journal and furnish us with contributions on developments in their respective countries.

We hope, during the next few months, to be making continual additions to our list of foreign correspondents. Meantime we wish to convey to all of those who have already accepted our invitation our grateful appreciation of their services in aiding the dissemination of information on Better Lighting.—Ed.)

UNITED STATES.

PROFESSOR E. C. CRITTENDEN (*President of the Illuminating Engineering Society in the United States*):

DEAR MR. GASTER,

I wish to acknowledge your letter of February 2nd and to thank you for the copies of Mr. Walsh's paper which were enclosed.

I appreciate very highly the honour of being nominated as a vice-president of your Society, and will be most pleased to accept this position for the current year. . . .

We have noted with interest your plans for enlarging the scope of the *Illuminating Engineer*. . . . I shall be glad to keep your journal in mind and to send you any notes which may appear to be of possible interest.

With best wishes for the success of your enlarged journal, I remain,

Sincerely yours,
E. C. CRITTENDEN, *President.*

MR. PRESTON S. MILLAR (*Past President of the Illuminating Engineering Society in the United States, New York*):

DEAR MR. GASTER,

I am very much pleased by the broader scope of the new journal, and trust that it will be a power for better lighting in England as well as a co-ordinating influence among those upon whom the progress of lighting depends.

With best wishes for success, I remain,

Yours very truly,
PRESTON S. MILLAR.

PROFESSOR A. E. KENNELLY (*Past President of the Illuminating Engineering Society in the United States*):

DEAR MR. GASTER,

Many thanks for your kind letter of the 16th March. I am glad to see that the *Illuminating Engineer* is taking extended form.

With all kind wishes,

Yours very sincerely,
A. E. KENNELLY.

DR. H. E. IVES (*New York*):

DEAR MR. GASTER,

I have your letter of March 16th suggesting that I continue to be a corresponding member of the Illuminating Engineering Society. Let me say that it would give me great pleasure to do this.

Very truly yours,
HERBERT E. IVES.

FRANCE.

PROFESSOR J. BLONDIN (*Secretary of the Comité français de l'Eclairage et du Chauffage, Paris*):

DEAR SIR,

I must thank you cordially for the honour you have kindly done me in suggesting that I should continue to serve as a corresponding member of the Illuminating Engineering Society.

I will do all that is possible to keep you informed of novel developments in illumination which come before my notice. The question of "Better Lighting" is now receiving attention in France. In particular the *Compagnie des Lampes* is undertaking a campaign in favour of proper lighting. In addition the *Comité français de l'Eclairage et du Chauffage* will shortly form a committee for the study of illumination and review work in this field.

There is therefore a prospect that we shall be able to send you some information on this subject.

With kind remembrances, believe me,

Yours sincerely,
J. BLONDIN.

PROFESSOR A. BLONDEL (*Paris*):

DEAR MR. GASTER,

I thank you for your kind letter of the 12th March, and I will endeavour to send you, during the current month, an article on illumination-photometres and their applications.

I congratulate you on the new developments of your work in extending the influence of your journal, and I trust that, thanks to your competent and persevering enterprise, you will obtain a large circulation and all possible success.

With kind remembrances, believe me,

Yours sincerely,
A. BLONDEL.

PROFESSOR TH. VAUTIER (*First President and now Honorary President of the International Illumination Commission, Lyons*):

DEAR SIR,

I thank you cordially for your letter of the 12th inst. and the copy of the *Illuminating Engineer* which you have kindly sent me. I congratulate you sincerely on the important improvements which you have introduced in the journal, notably the larger page which will allow the publications of important illustrations and extensive tables. The form seems to me entirely appropriate, and I do not doubt that under your competent and careful editorship it gives eminent satisfaction to its numerous readers in England and abroad.

I accept with pleasure your suggestion that I should continue to act as one of your corresponding members, and I shall be glad to receive your very interesting paper.

Wishing you the best success in the cause to which you have so long devoted your praiseworthy efforts, believe me,

Yours sincerely,
TH. VAUTIER.

ITALY.

SIG. M. BOHM (*Member of the National Illumination Committee in Italy, Milan*):

DEAR MR. GASTER,

Hearty congratulations on the progress made and perfection attained by the journal which you have founded. I hope that it will attain a wide circulation and prove a source of great satisfaction to you.

With kind regards, believe me,

Yours sincerely,

M. BOHM.

GERMANY.

PROFESSOR DR. W. WEDDING (*Past President of the Illuminating Engineering Society in Germany, Berlin*), after referring to the circumstances that have hindered international treatment of illumination during recent years, continues:

In the meantime the Illuminating Engineering Society in Germany has developed successfully, in spite of all the difficulties arising from the war. I succeeded Dr. Warburg, the original President, during four years of activity. Now I am in the position of an honorary member, as well as Chairman of the Council, and am doing my best to further the interests of the Society. In addition, I am engaged in developing the Illuminating Engineering Laboratory originated by me in the Technische Hochschule in Charlottenbourg.

As a slight indication of work achieved by our Society, I am sending you the Recommendations of the D.B.G.,* and must thank you for the copy of your January issue which you have kindly sent me. I trust that the journal conducted by you will progress and develop further with the same success as hitherto.

Your suggestions with regard to my co-operation are particularly appreciated, and I will gladly do what I can to help. . . . There are many questions which can and must be brought to the public notice, and so far as my health permits I will gladly be of assistance. Similarly the training of experts on illumination on the basis of past experience, and the promotion of concerted action on the part of engineers, architects and medical men (both ophthalmologists and hygienists) must be taken up much more actively than in the past.

With best wishes, believe me,

Yours sincerely,

W. WEDDING.

DR. H. LUX (*Co. Editor of "Licht und Lampe," official organ of the Illuminating Engineering Society in Germany, Berlin*):

DEAR MR. GASTER,

I received the copy of your journal, and will gladly arrange for you to receive particulars of developments in Germany in the field of illuminating engineering.

I take the opportunity to enclose two copies of the recently issued Recommendations, emanating from the German Illuminating Engineering Society,* on the lighting of buildings, streets and open places, and factories and other workrooms.

Yours sincerely,

H. LUX.

DR. HEYCK (*Messrs. Körting & Mathiesen, Leipzig, Germany*):

DEAR SIR,

I have received your letter of February 27th, and must cordially thank you for your invitation to act as one of your corresponding members in Germany. I have read your journal for many years, and have always learned much from it. Therefore it is a special pleasure to me to be allowed to co-operate, and also to continue to receive it in the future.

I will gladly bear you in mind, and try to send you information whenever opportunity occurs. Meantime allow me to send you several papers that I have recently written. Possibly these may be of interest to you; if so, it would give me great pleasure if you could make use of them in any form in your publication.

Believe me,

Yours sincerely,

HEYCK.

* The first instalment of these recommendations, kindly sent us by Dr. Wedding and Dr. Lux, is reproduced in this issue on pp. 96-97.—Ed.

SWITZERLAND.

PROFESSOR J. LANDRY (*Department of Industrial Electricity, Lausanne University, Switzerland*):

DEAR MR. GASTER,

I have had the pleasure of receiving your kind letter of March 13th, in which you draw my attention to the changes in your journal, for which many thanks.

I wish to convey my sincere wishes for the continuation of the success by which your venture has been attended during recent years, and I congratulate you on the development of the work and journal of the Society, under your direction.

Believe me,

Yours sincerely,

JEAN LANDRY.

RUSSIA.

MR. S. MAISEL (*Leningrad, Russia*):

DEAR MR. GASTER,

Having been absent from Leningrad, I have not had an opportunity before of replying to your kind letter of February 2nd. I now thank you cordially for the letter and for the copy of the *Illuminating Engineer*, which has interested me in the highest degree. I hope that the new form of the journal will widen the circle of its readers and thereby contribute to the dissemination of knowledge of illumination.

I shall be very glad to act as your correspondent, and hope to send you in the near future a short account of the position of illuminating engineering in Russia.

Believe me,

Yours sincerely,

S. MAISEL.

AUSTRIA.

PROFESSOR DR. H. STRACHE (*Tech. Hochschule, Vienna*), writes:

It was a great pleasure to me to hear from you after so long, and to see that your journal has developed so well. . . . I am not so much occupied with illumination as formerly, but I am certainly a member of the Illuminating Engineering Society in Austria, and may have occasional opportunities of sending you notes on its proceedings. If this will answer I shall be very happy if you will continue to regard me as one of your corresponding members.

Amongst other letters received we should like to mention that from Herr Göhrum, Director of the Gas Works at Stuttgart, who expresses his appreciation of the work of the Journal. Also we have heard from the Editor of *Elektrotechnik and Maschinenbau*, with which is associated *Lichtechnik*, the journal of the Austrian Illuminating Engineering Society, who kindly expresses his willingness to be of service, and is also putting us in touch with the Professor Ondracek, of the above body.

Others who have written expressing interest in the Journal include Professor S. W. Ashe (Pittsburgh, U.S.A.), and Mr. V. R. Lansingh (New York), Dr. Bertelsmann (Berlin) and Dr. W. Steiner (Vienna).

The above are only the first instalment of letters received in response to our appeal for co-operation. We trust that in due course all the chief countries will be represented, and that our arrangements for the receipt of news from abroad will be made much more complete.

A CORRECTION.

We regret that by an oversight the name of Mr. A. P. Trotter, formerly President of the Illuminating Engineering Society and well known to our readers for his pioneering work in illumination and photometry, was omitted from the List of Members of the National Illumination Committee published in our February issue (p. 40). This error has since been rectified in the reprints circulated by the Committee. We are glad to be able to record that the Committee will continue to benefit by Mr. Trotter's experience; the only change in membership being that Mr. J. M. G. Trezise is taking the place of Mr. W. C. Clinton.

Notes for the Photometric Laboratory

II—The Determination of Mean Spherical Candle Power by the Point to Point Method

By H. BUCKLEY, B.Sc.

(From The National Physical Laboratory.)

(Concluded from Page 70, March, 1925.)

Tchebicheff's Method of Determining Mean Values.

In Gauss's method of determining mean values different weights are attached to observations at different angles. Tchebicheff has proposed a method of selecting ordinates which gives equal weight to all observations. As applied to mathematical functions, Tchebicheff's method requires about twice as many ordinates to give the same accuracy as does Gauss's. When the observations are subject to unknown errors Tchebicheff's method has an advantage inasmuch as all the errors are equally weighted and the probable error of the mean deduced from them is a minimum. Since in determining mean spherical candle-power the greatest uncertainty is in the selection of the planes in which to make measurements, Gauss's method is the more reliable, though in view of the unequal weighting it gives to observational errors there may be very little between the two.

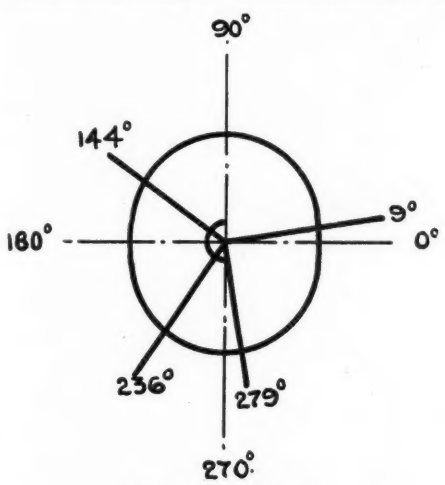


Fig. 6.—Gasfilled Lamp.

The values of the angles in a range from 0° to 90° for Tchebicheff's method, with three, four and five observations are given in the appendix. The mean value is obtained by dividing the sum of the observations at the given angles by the number of observations.

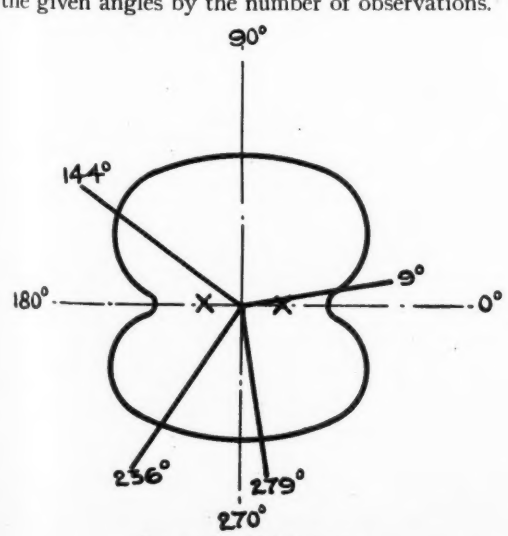


Fig. 7.—Two-Mantle Burner.

Similar considerations to those in the portion of these notes dealing with Gauss's method indicate how observations at these angles can be used to obtain the mean horizontal candle-power of the following sources.

Gasfilled Lamp.

Mean horizontal candle-power =
$\frac{1}{4}$ (c.p. 9° + c.p. 144° + c.p. 236° + c.p. 279°).

Two-Mantle Burner.

As for gasfilled lamp.

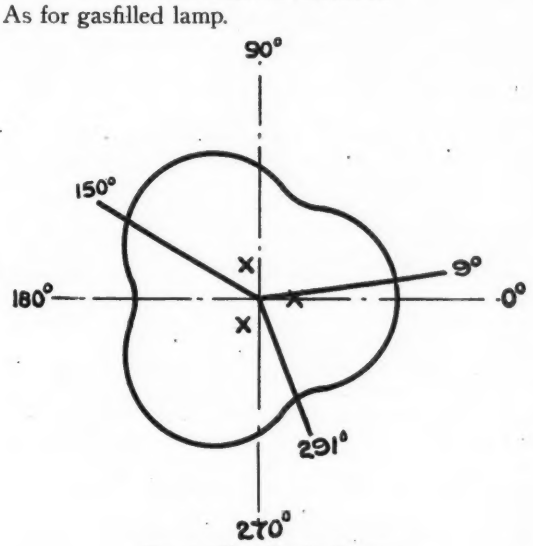


Fig. 8.—Three-Mantle Burner.

Three-Mantle Burner.

Mean horizontal candle-power =
$\frac{1}{3}$ (c.p. 9° + c.p. 150° + c.p. 291°).

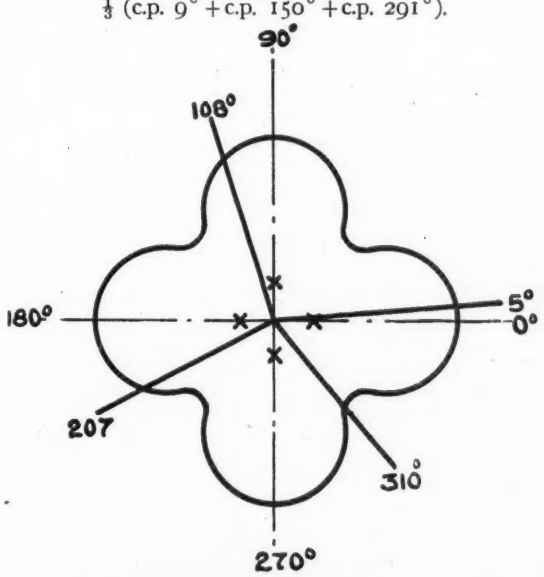


Fig. 9.—Four-Mantle Burner.

Four-Mantle Burner.

Mean horizontal candle-power =
$\frac{1}{4}$ (c.p. 5° + c.p. 108° + c.p. 207° + c.p. 310°).

Test of the Method on an Actual Case.

On submitting Tchebicheff's method to the same test as was Gauss's we find for the mean horizontal candle-

power of the four-mantle cluster, whose horizontal polar curve was given in Fig. 5:—

152 candles starting point at 0°.
154 ,, ,, ,, 90°.
144 ,, ,, ,, 180°.
148 ,, ,, ,, 270°.

The true mean horizontal candle-power is 151 candles. These results compare very favourably with those deduced by Gauss's method.

Choice of Angles in Vertical Planes.

Having determined the vertical planes in which candle-power measurements are to be made, we must now consider at what angles in these planes they should be made.

Since measurements are usually to be made in four planes, it will be advisable to restrict the number in each plane as much as possible. Measurements in these planes will give four values of the mean spherical candle-power, which must be weighted unequally in Gauss's method and weighted equally in Tchebicheff's method in order to get the correct result for the source as a whole.

If the vertical planes chosen are those derived by Tchebicheff's method we may take the alternate angles of the ten Russell angles to a quadrant in alternate planes.* Thus, if the first plane observations are made at 18·2°, 41·4°, 56·6°, 69·5°, 81·4°, 92·9°, 104·5°, 116·7°, 130·5°, 148·2° (measured from the vertical), the observations in the second plane should be at 31·8°, 49·5°, 63·3°, 75·5°, 87·1°, 98·6°, 110·5°, 123·4°, 138·6°, 161·8°. This method would retain the advantage of the ten Russell angles per quadrant in deducing the mean spherical candle-power, and only 40 observations would be necessary (an extra one at 0° could conveniently be taken if desired to make the polar curve complete at a point where there is, however, scarcely any contribution to the mean spherical candle-power).

The apparatus for determining polar distributions is not always adapted for observations at the Russell angles. In this case a similar alternative treatment of observations at 10° intervals would enable the mean polar curve to be deduced, while the mean spherical candle-power would be determined by means of the Rousseau diagram or any other method.

If the vertical planes chosen are those derived by Gauss's method it is not possible to adopt this alternate method of taking observations owing to the unequal weights attached to the observations in each plane. In this case the observations should be taken at the five Russell angles in each quadrant, i.e., ten observations in each plane at 25·6°, 45·6°, 60°, 72·5°, 84·3°, 95·7°, 107·5°, 120·0°, 134·4°, and 154·4°, and the mean polar curve deduced from the weighted observations, an observation being taken at 0° for the sake of completeness.

If the apparatus is not adapted for observations at the Russell angles, observations at 10°, 30°, 50°, 70°, 90°, 110°, 130°, 150°, 170° could be made in each plane, and the mean polar curve and mean spherical candle deduced.

Reduction of Number of Observations to Twenty.

Another reduction in the number of observations can be made by a further alternative treatment of the observations in the separate planes.

Thus, with Tchebicheff's method, using four planes and ten Russell angles to a quadrant, observations should be taken at the angles given below:—

Plane 1. 18·2°, 56·6°, 81·4°, 104·5°, 130·5°.
Plane 2. 41·4°, 69·5°, 92·9°, 116·7°, 148·2°.
Plane 3. 31·8°, 63·3°, 87·1°, 110·5°, 138·6°.
Plane 4. 49·5°, 75·5°, 98·6°, 123·4°, 161·8°.

The mean spherical candle-power is obtained as the mean of the above 20 observations. For the purpose of the polar curve two additional observations at 0° and 180° should also be taken.

If the apparatus is not adapted for observations at the Russell angles, the following arrangement of the observations will enable the polar curve to be drawn, and the mean spherical candle-power can then be deduced by means of the Rousseau diagram or other method.

* This method of treatment is not perfectly sound, but the error involved is negligible.

Plane 1. 0°, 40°, 80°, 120°, 160°.
Plane 2. 20°, 60°, 100°, 140°, 180°.
Plane 3. 10°, 50°, 90°, 130°, 170°.
Plane 4. 30°, 70°, 110°, 150°.

Similar schemes can be easily arranged for the case when three planes are considered.

The Practical Superiority of Tchebicheff's Method.

It will be seen from the above considerations that Tchebicheff's method, though not as sound theoretically as Gauss's method, has decided advantages, inasmuch as all the observations are equally weighted, and that used in conjunction with observations at the Russell angles the mean spherical candle-power can be deduced as the arithmetical mean of twenty observations. In all cases except those obviously requiring special treatment Tchebicheff's method gives very satisfactory results.

It is useful in the application of these methods to have diagrams of the various cases which arise in practice showing at once the angles at which observations should be made. One of these is shown in Fig. 10. Furthermore, in the design of apparatus for determining polar distributions it will be of advantage if it is arranged that observations can be made at any angle whatever, and not merely at 5° or 10° intervals, or at any particular set of Russell angles.

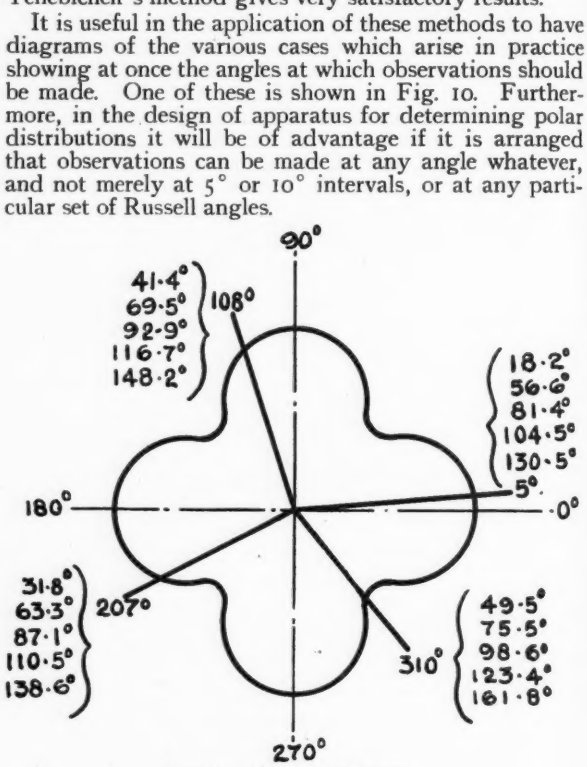


Fig 10.—Four-Mantle Burner.

Use of Gauss's and Tchebicheff's Angles in Vertical Planes.

It is obviously possible to apply the same treatment to each vertical plane as was applied previously to the horizontal plane either by Gauss's method or Tchebicheff's method. In either case a satisfactory formula for mean spherical candle-power could be obtained. For Gauss's method with four observations to each quadrant the mean spherical candle-power =

0·014 (c.p. 6°) + 0·128 (c.p. 30°) + 221 (c.p. 60°)
+ 0·136 (c.p. 84°) + 0·136 (c.p. 96°) + 221 (c.p. 120°)
+ 0·128 (c.p. 150°) + 0·014 (c.p. 174°).

This is not a very convenient form for calculation. Tchebicheff's method similarly gives an unequally weighted formula when applied to a spherical distribution.

Effect of Irregularities in the Polar Distributions.

These considerations have been based on the assumption that the polar distributions can be represented by smooth curves. Experience shows that this is not exactly the case. On every polar curve there are apparently arbitrary variations from what can be regarded as a smooth curve, though, in general, points on the actual curve are not more than five or six per cent. from the smooth curve. The variations can thus be regarded as accidental variations from the true smooth curve expressing the polar distribution of the source.

Now the theory of errors shows that with about 20 observations on a given quantity the probable error of the mean deduced from them is less than one-fifth the total range of the variations. In this case the total range of the variations is usually less than 12 per cent., so that the probable error of the mean spherical candle-power is of the order of 2 per cent.

Application to Other Types of Light Distribution.

The preceding arguments have been developed with regard to gasfilled lamps and gas burners. They can, however, be applied to light sources which consist of diffusing shades and reflectors. In these cases the polar curves are usually much smoother than for the bare sources, so that the accuracy should be increased. For light sources which are used in conjunction with mirrors or lenses and which produce or tend to produce pronounced focussing effects and small beam divergences, it will be necessary to consider each case on its merits, and considerably different arrangement of the angles at which observations are made will be required.

Conclusion.

The above considerations may at first sight give the impression that the problem of determining mean spherical candle-power has been complicated, but it must be remembered that what is wanted is the determination of the least number of observations and their best selection to give the best possible result.

The above principles will enable the mean spherical candle-power to be obtained from about 20 readings, and will give as good a result as is possible from these 20 readings. In addition, they enable the mean polar curve to be determined.

Appendices.

Gauss's angles and weights for three, four and five observations in the range 0° to 90° :—

Three observations—
Angles ... 10·2°, 45·0°, 79·8°.
Weights . 0·278, 0·444, 0·278.

Four observations—
Angles ... 6·2°, 29·7°, 60·3°, 83·7°.
Weights . 0·174, 0·326, 0·326, 0·174.

Five observations—
Angles ... 4·2°, 20·8°, 45·0°, 69·1°, 85·7°.
Weights . 0·119, 0·239, 0·284, 0·239, 0·119.

Tchebicheff's angles for three, four and five observations in the range 0° to 90° :—

Three observations—
13·1°, 45·0°, 76·9°.

Four observations—
9·3°, 36·6°, 53·4°, 80·7°.

Five observations—
7·6°, 28·1°, 45·0°, 61·9°, 82·4°.

Lectures on Illuminating Engineering

THE first two lectures of the series on "Illuminating Engineering," arranged at the Polytechnic (Regent Street, London), took place on Monday, April 20th, and Wednesday, April 22nd.

Mr. Leon Gaster, Hon. Secretary of the Illuminating Engineering Society, made a few introductory remarks emphasizing the importance of study of illumination and realization of the benefits of good lighting, and explaining the objects of the course of lectures which covered a wide range of subjects.

The Nature of Light and its Measurement.

The initial lecture on the above subject was delivered by Mr. J. W. T. Walsh, of the National Physical Laboratory. The lecturer began with a short statement of the aims of illuminating engineering, and referred to progress made during the past few decades. After a brief explanation of the nature of light and the varying sensitivity of the eye to luminous energy throughout the spectrum, Mr. Walsh then dealt with the chief photometric quantities and units, viz., luminous intensity and candle-power, luminous flux, brightness and reflection factor. He exhibited an electric lamp used as a standard of candle-power at the National Physical Laboratory.

After pointing out the important part played by measurement in any science which aimed at taking its place among the exact sciences, the lecturer demonstrated the inability of the eye to judge absolute values, and the consequent necessity for basing all measurements on adjustment to equality, a condition of which the eye was capable of judging with fair accuracy.

Mr. Walsh then went on to describe methods commonly adopted for making measurements of candle-power, using a photometric head and bench. The simple Bunsen head with Rüdorff mirrors was shown in order to demonstrate the method, and the contrast form of Lummer-Brodhun head was described.

Passing on to flux measurements, the lecturer explained the use of the integrating sphere, and showed how standards of flux were obtained by means of candle-power measurements in different directions.

The method of making illumination-measurements was explained, first in general terms and then with particular reference to certain illumination-photometers exhibited on the lecture table and illustrated by lantern slides. The use of these photometers for making measurements of brightness and of the reflection factors of surfaces was explained, and some precautions necessary when using portable illumination-photometers were mentioned.

The lecture was illustrated throughout by lantern slides, and the instruments shown were examined after the lecture by those present.

Light in Relation to Vision and Health.

The second lecture, by Dr. James Kerr, on the above subject, was delivered on April 22nd. In his introductory remarks, the lecturer recalled a remark of Professor Sylvanus Thompson, nearly 20 years ago, that a bare electric lamp, which dazzled the eye at night, could burn almost unnoticed in the daytime. This effect furnished the solution to many riddles in illumination.

The lecturer then illustrated the "machinery of vision," and explained the process of adaptation of the eye, which takes place only slowly. Hence sudden and abrupt changes in brightness should be avoided. He showed how, in addition to pupil-contraction, there is gradual movement of the pigment granules; how excess of light confuses the clarity of the image and causes painful dazzle-effects. The effect of excessive contrast was illustrated by reference to the appearance of motor-headlights by night, and other manifestations of glare.

Dr. Kerr next explained another process of vision—the accommodation of the eye by adjustment of focus. Severe efforts of accommodation—the "peak load"—should only be endured for a short time. When objects are fine and the illumination insufficient the strain on the eye is accentuated. He also dealt with the prejudicial effects of glare from shiny surfaces. The remedy for glare was not to reduce the lighting, but to secure better distribution.

Another illustration of the drawbacks of insufficient light was afforded by the curious condition set up in the eyes of some coal-miners (nystagmus). The machinery of the eye got out of gear owing to the dark surroundings and low illumination, and the eyes, instead of being held steady, are constantly moving by little jerky motions. Here again the remedy was better illumination.

The next section of the lecture dealt with some recent discoveries in connection with the beneficial influence of sunlight. People who went for a holiday to the coast or into the country came back sun-burned, and in improved health; in the high mountains of Switzerland the effect was particularly evident. This was originally thought to be merely the result of air and exercise, until Hess and Ungar, in America three years ago, found that the light of a quartz tube mercury-vapour lamp had a healing effect on ill-nourished and rickety rats. This beneficial effect of sunlight has since been applied to children.

In conclusion, Dr. Kerr referred to various curiosities of vision; notably the singular effect demonstrated before the Illuminating Engineering Society a few years ago, when it was shown that rapidly moving machinery, illuminated by suitable intermittent light, could be made to appear stationary.

Recommendations on Illumination

Issued by the Illuminating Engineering Society in Germany

(Slightly Abbreviated.)

(It is always of interest to compare recommendations on illumination presented in different countries. By the courtesy of Dr. H. Lux, one of our esteemed correspondents in Berlin, we have received a copy of some recommendations recently issued by the Illuminating Engineering Society in Germany and we are giving a summary, slightly abbreviated, of this report. We understand that a supplementary illustrated leaflet explaining the application of these principles in detail, is in course of preparation.)

I—Recommendations on the Lighting of Interiors

THE equipment of buildings with natural and artificial light should fulfil requirements of suitability (zweckmässigkeit), health, efficiency and artistic appearance.

Suitability.

(1) Every room to be illuminated must be provided with illumination suitable for the purpose served by this room. A distinction is drawn between General Illumination and Local Illumination (Platzbeleuctung).

General illumination serves to facilitate movements of persons and material, or as a supplement to local illumination, or as the "working illumination." Local illumination, on the other hand, is always provided for the purpose of enabling work to be done.

(A) *General Illumination*, in so far as it serves merely to facilitate movements about the room, is defined in terms of the average illumination on an horizontal surface one metre above the floor. The following values should be provided:—

(a)	In rooms of little importance	1 lux*
(b)	On landings, staircases, etc. ...	5 ,,
(c)	In waiting rooms and work-rooms occupied by a number of persons	10 ,,

(B) *Working* or *Local Illumination* (defined as the average illumination on the working surface or at the place where work is done):—

(d)	For rough work	15 lux
(e)	For medium work	40 ,,
(f)	For fine work	60 ,,
(g)	For very fine work	90 ,,

(In the case of work done on dark materials considerably higher illumination is required than when the material is light in colour.)

All lighting equipment (windows, lamps and lighting accessories, globes, reflectors, etc.) must be so maintained, as regards cleaning of dust, replacement of lamps or mantles that have worn out, etc., that the illumination is not diminished below the essential values.

(2) General illumination should neither be completely "shadowless" nor subject to inconvenient shadows on the floor, walls or objects in the room.

(3) Care should be taken that no troublesome variations in illumination occur over the working area; similarly inconvenient flickering of light-sources should be avoided.

(4) The installations should be so designed that sharp contrasts in the illumination of adjacent spaces are so far as possible avoided.

(5) The positions assigned to light-sources should be indicated in the plan of the building.

(6) In dealing with buildings of importance it is recommended that an illuminating engineer should be consulted when the plans of the building are under consideration.

* One Lux (Hefner) is equal to 0·0837 foot-candles. For a rough comparison, therefore, the above values may be approximately converted into foot-candles by dividing by ten.

Recommendations in the Interests of Health.

(1) The eyes should be protected against glare either from direct or reflected light.

(2) Individual sources serving for local illumination of working places should be screened if their brightness exceeds 0·75 candles (Hefner) per sq. cm.

(3) For general lighting sources of higher brightness may be used. The brightness, however, should not exceed five candles (Hefner) per sq. cm., if the sources are so situated that the angle between a line drawn from the eye to the source and an horizontal plane is less than 30°; otherwise the sources should be screened or enclosed in diffusing globes, etc.

(4) Prejudicial development of products of combustion or heat from light-sources should be prevented by suitable ventilation.

Efficiency.

Assuming that the requirements indicated above can be fulfilled in various ways, the method of light most conducive to efficiency is to be preferred.

Good Appearance of Rooms.

The lighting equipment of a room should be installed with due regard to artistic appearance; nevertheless essential practical requirements should never be sacrificed to this consideration. In the case of lighting installations in public buildings the co-operation of an architect should be obtained.

II—Recommendations for External Lighting

General Recommendations.

Wherever any considerable traffic, whether public or private, takes place in open spaces (e.g., in streets and squares, pathways in the vicinity of railways, docks, factory yards, etc.) artificial illumination ensuring public safety and guidance of traffic should be provided. The illumination of streets and squares should also satisfy requirements in regard to pleasing appearance.

Special Recommendations.

(1) *Illumination.* Illumination in open spaces is to be measured on an horizontal plane one metre above the ground, and should be expressed in terms of the average and minimum illumination measured on a spot free from shadows.

Conditions of Traffic.

	Average Illumination (Lux)		Minimum Illumination (Lux)
On footpaths and tracks	0·2—0·5	...	0·1—0·3
On footpaths and tracks in the vicinity of railway lines, factory yards, docks, etc.	0·5—1·5	...	0·2—0·5
In streets and squares:—			
With little traffic	0·5—1·5	...	0·05—0·3
With medium traffic	1·5—5	...	0·3—1
With heavy traffic (also approaches to railway stations and places where people assemble in large towns) ...	5—10	...	1—2

(2) *Quality of Lighting.* Sharp contrasts in illumination and fluctuations in the illumination due to flicker of light-sources are to be avoided; and likewise the casting of sharp shadows on places where there is heavy traffic.

Troublesome glare from public lamps, or from sources in shop windows, illuminated signs, etc., should be avoided; excessive brightness of sources should accordingly be diminished by the use of diffusing screens, etc.

Signal lights (to indicate obstructives, repairs, tramway-crossings, etc.) should not be masked by the presence of adjacent public lamps, or liable to be confused with them.

(3) *Working Conditions, Maintenance, etc.* The artificial illumination of open spaces is (in Germany) necessary: —

(a) In the six winter months from three-quarters of an hour after sunset until three-quarters of an hour before sunrise;

(b) In the six summer months from one hour after sunset until one hour before sunrise.

At times when there is less than normal traffic the illumination can be diminished below the requirements indicated above, the alteration corresponding to the nature of the street or public place and its importance.

Public lamps should be continuously maintained in good working order and regularly cleaned and maintained.

(To be continued.)

[The third section of the recommendations deals with the industrial lighting. We propose to deal with this in our next issue.—Ed.]

Some Notes on Artificial Daylight

By An Engineering Correspondent

ALTHOUGH not a great deal has been heard about artificial daylight recently it is understood that steady progress in its applications in this country have been made. It may be recalled that two distinct methods of effecting the change in spectrum of the artificial light exist. In the first method (as exemplified in the Sheringham Daylight units) the system is indirect. Light from a gasfilled lamp is reflected upwards by means of a metal bowl below the lamp on to an extensive upper surface, on which is stencilled a pattern in ultramarine, emerald green and yellow—the ultramarine being by far the largest constituent. By suitably proportioning these elements a very close resemblance to natural daylight may be obtained.

The other method depends on transmission of light through a combination of tinted glasses. The lamp is housed in a metal reflector and the light passed downwards through the glass screens, which have to be selected and reproduced with considerable care. This is exemplified in the Lamplough Daylight Lamp. Both systems at present use gasfilled incandescent lamps, but there is no reason, in principle, why they should not be applied to other illuminants, such as incandescent gaslight or acetylene.

In both cases the resemblance to average daylight is claimed to be accurately maintained, and apparently practical experience shows that the exacting needs of dyers who undertake exact colour-matching can be satisfactorily met. It has been claimed that the use of pigments enables a specially smooth curve throughout the spectrum, free from sudden "kinks" to be obtained. In the selection of glasses the avoidance of such kinks calls for considerable skill and scientific analysis, but in this case, too, a good imitation of daylight seems possible.

A distinguishing feature of the method based on reflection of light from pigments is the diffused character of the light. It may be claimed that the "spreading" of light characteristic of indirect methods, produces an effect more closely akin to daylight than concentration. On the other hand, the use of a focusing reflector, possible when transmission through tinted glass is used, enables a relatively higher illumination to be obtained immediately under the lamp.

In either case the loss of light inevitably occasioned by accurate imitation of daylight is considerable. It may be doubted whether, in the case of an accurate lighting unit, the surviving light amounts to more than 15 or, at most, 20 per cent. of the original. But to those engaged in trades where accurate colour-matching is essential, this "inefficiency" is not of very great consequence in comparison with the advantage of being able to conduct their tests by artificial light, independent of the vagaries of the climate and the vast fluctuations both in the quality and intensity of natural daylight such as occur during the British winter.

The tendency is now towards the use of much higher illuminations than were furnished by the early "artificial daylight" units. Colour-matching processes, hitherto done only by the best daylight conditions, require a high illumination, and the nearer we can approach the intensity of good natural daylight the better. It may be assumed that at least 5 foot-candles is desirable, and in many cases it would be well to attain 10 or even 20 foot-candles. One recent illustration of the use of artificial daylight for a process where very high illuminations are required is the treatment of operating tables in hospitals. The surgeon requires very high intensity, and in many cases it is likewise a considerable advantage to be able to reproduce the colour-revealing qualities of natural daylight as well. Mr. Norman Macbeth, in a recent contribution to the *Electrical World*, described an artificial daylight installation in a Boston hospital, where as much as 12 kw. were allotted to the light of the operating table. Even so the cost of energy during an operation is only about equal to that of the anæsthetic used. An illustration in the original paper shows twelve artificial daylight units recessed into the ceiling above the table, so that the whole of the area is flooded with diffused light. Manufacturers are now considering more favourably a generous use of energy, flooding the entire room with artificial daylight, so that natural daylight is effectively imitated as regards diffusion and intensity as well as colour.

Accuracy of reproduction of daylight is an important consideration. It has been urged in this journal that a standard of "white light" to which units claiming accuracy could be compared, should be available. Such a standard is clearly needed. It should be possible to discriminate between scientifically constructed and designed units, imitating daylight sufficiently closely for exacting colour-matching tests, and other units which only furnish a very approximate imitation. The latter units may have their uses, for example, in drapers' shops, for florists, etc., where it is merely desired to give the customer an idea of the appearance of objects by daylight. But they should be graded in terms of accuracy.

The obvious difficulty with which scientists are at present grappling is that there is no precise agreement as to what constitutes "normal daylight," nor any means by which this can be accurately and consistently reproduced. Good artificial daylight units themselves come nearest to a constant reproduction! But, from the scientific standpoint, the permanency and reproducibility of pigments and coloured glasses needs to be authoritatively tested; though experience with the best forms of units is promising, artificial daylight is a comparatively recent innovation, and data covering a considerable period of time are needed. It is, however, possible, as Mr. Ord has shown,* to analyse the light from artificial daylight units with the spectrophotometer and detect abnormalities liable to affect accuracy in colour-matching. Such tests, supplemented by actual inspection of the appearance of delicate colours, afford the best available means of ascertaining the degree of accuracy with which "normal daylight" (e.g., light from a white north sky) is imitated.

* *Illuminating Engineer*, Vol. XVI, 1923, p. 167.

The Lighting of Post Offices

A Study of the Effect of Conditions of Illumination on Vision and Efficiency

WE have received from one of our correspondents, Dr. J. E. Ives, of the United States Public Health Department, a copy of the account of the exhaustive series of tests recently carried out by him and others associated with the U.S.P.H.S. into the lighting of post offices. The investigation is noteworthy as an illustration of the good effects attending the co-operation of the physicist and the ophthalmic surgeon. Dr. Ives had the assistance of Drs. L. R. Thomson and Louis Schwartz, both surgeons, and Mr. N. P. Bryan, a scientific assistant. A feature is the correlation of tests of vision and efficiency with data on illumination.

Nature of Tests.

The introductory part of the treatise explains the nature of the tests undertaken. These fall into three main groups: (1) Occupational and process studies; (2) Illumination tests; and (3) Studies of defects of eyesight amongst post office operators.

The first group of tests included an investigation of the various processes carried on in a large postal department, a determination of the effect of varying conditions of illumination on speed and efficiency, and an examination of the economic advantages of increased illumination. In the second part of the investigation a record of actual working conditions, as regards illumination, was taken, and there were further tests to ascertain the most suitable conditions (including the desirable intensity of illumination) for various kinds of post office work. The eyesight tests were so arranged that all occupational groups were represented.

The Work of a Post Office.

Few people, probably, have a proper conception of the great variety of work involved in a large postal system. The report describes the collection of mails, their transference to the sorting and dispatching departments and the use of the stamp cancellation machines. A number of suggestive points are raised. It is mentioned for instance that hitherto pigeon-holes in sorting cases have been backed by a network of wire-mesh. These, it is found, create a confusing effect on the eyes of some workers (possibly those suffering from astigmatism), especially when lights or moving objects are on the other side of the case. An improved method of backing is suggested in the recommendations (given later).

From the "primary" separation cases a "sweeper" takes the mail to other cases, where a secondary separation takes place, the eyework involved being similar and requiring the reading of the city and state address on each piece of mail. Special separations are made in the case of damaged mail which is collected in baskets and taken to a repair table. In the subsequent process of sorting letters and parcels into bins for dispatching the eyework is twofold; the operator must read the address and then refocus his eyes on the proper bin and watch the package until it has entered it. Thus the eye must constantly change its focus. Pouching racks for the transference of mail into bags have been introduced. The average speed of operation is relatively slow, and most of it takes place between five and eight o'clock at night. The report next describes the processes of registration, dealing with money orders and other special service. Regular employees (with the exception of those doing purely clerical work) work in three shifts of eight hours. In general the shifts rotate so that workers have a day-shift and a night-shift in succession.

An Illumination Survey.

The next item in the report is an elaborate survey of conditions of illumination in various departments and post offices, results being assembled in tables and illustrated by numerous diagrams. The chief feature of these readings was the considerable variation in values of illumination provided. In some cases the values were relatively high; but in general, even when the average value was fairly good, the range for the same process was excessive, values well below one foot-candle being often recorded.

Examinations of Eyesight.

Attention is drawn to the tiring nature of the work done in examining mail; addresses vary greatly, being sometimes typewritten and sometimes handwritten in fine or more or less illegible characters. Another factor is the use of ink on coloured papers. In general, it has been found that black on yellow is more easily read than red on green. A letter-separator reads on an average between thirty and forty addresses a minute. His work may require adjustment of the muscles controlling the eye eighty times a minute. Hence the importance of good illumination in reducing to a minimum the strain of this process. If the illumination is low blurred images are apt to result, because the dilated pupil diminishes acuteness of vision. Speed of vision is also reduced, and the excessive effort of eye-adjustment results in fatigue.

In the examination circulars were addressed to employees enquiring whether they had any complaints about their eyes, suffered from headaches, were conscious of eyes becoming tired during work, or found that the light was trying to the eyes. They were also asked whether they used glasses, and the glasses were examined and tested at the same time as the employees' sight. The results at several post offices are tabulated in detail and the nature of eye-defects analysed. (In passing it is of interest to note that a number of cases of nystagmus are recorded—a disease generally associated entirely with work in mines.)

One important point brought out by the tables is that acuteness of vision is usually lower for the letter-separators than for employees generally, and this discrepancy tends to increase with years of service. Thus in the five-ten years service group the percentage of normal vision was 9 per cent. less, and in the over ten years service group 18 per cent. less. It appears therefore that the intensive eyework done in this department tends to cause more rapid deterioration of vision.

Another feature is the existence of an almost constant difference in the percentage of normal vision found in the case of workers at the General Post Office and the City Hall Post Office. After making every effort to eliminate all such factors as sex, age, length of service, etc., it is believed that this variation is due to difference in the conditions of illumination; also possibly to the fact that at the City Hall the percentage of workers operating exclusively by daylight is less.

An instructive table is presented showing the percentage of persons with normal vision in one or both eyes found in different industries. The worst results are recorded for the garment-making industry (40 per cent.). The chemical industry comes next and the New York post offices come fourth on the list (64·2 per cent.).

Desirable Conditions of Illumination and Effect on Production.

In the next section of the report the work in post offices and the desirable conditions of illumination are further reviewed. Quotations are made from recent codes furnishing an indication of illumination necessary in other industries; the causation of glare and its elimination are discussed, and possible forms of lighting fittings are illustrated and analysed.

We now come to one of the most valuable features in the report—the comprehensive tests made with the object of relating conditions of illumination to speed and efficiency of working. While the authors explain that the tests are essentially experimental they enable some fairly definite conclusions to be drawn. The workers tested were divided into groups according to eyesight. In a general way all the groups increased their production when the illumination was improved. *But the difference was most marked in the case of employees having relatively poor sight.* Thus the A and B groups, with

the best vision, reached their maximum production with an illumination of 8 foot-candles, the C group, with the poorest vision, at 14 foot-candles. The difference between the highest and lowest time for sorting a specified number of letters, with the range of illumination provided, was 3 minutes for the A group, 4·38 minutes for the B group, and 5·34 minutes for the C group. The inference is that people with poor sight require a higher illumination than those with relatively good vision, in order to do their best work. Put in another way, the mean gain in production for the normal group under 8 foot-candles was 16·6 per cent., and for the subnormal group 26·2 per cent. Similar conclusions apply to accuracy of work. The number of errors decreased as the illumination was advanced, being 3·08 per operator under 2·8 foot-candles, 2·83 under 3·6 foot-candles, 1·92 under 8 foot-candles, and 1 under 14 foot-candles. Tests with special coloured cards led to similar conclusions.

Economic Advantages of Better Illumination.

On the basis of these tests the economic advantages of better lighting can be calculated. In the case of a typical office the total pay roll for 1921 amounted to 6,746,039 dollars. About half the time of workers is spent under artificial lighting, so that 3,373,000 dollars represents the amount paid to workers whilst working under artificial light. One per cent. of this amount is approximately 34,000 dollars. It is calculated that the increased cost involved in providing better lighting (raising the illumination from 3·6 to 8 foot-candles) is 29,300 dollars, which is quite close to the above sum. Hence any gain in efficiency of 1 per cent. or more would offset the cost of the improved lighting. On the basis of the test described above an average increase in production of 4·4 per cent. was taken as the average gain in efficiency likely to be realized. This figure was arrived at for a single post office, and no doubt further investigations are needed before a very precise relation between better lighting and production can be put forward. It is believed, however, that the results so far obtained amply justify the conclusion that *the gain in efficiency is certainly more than the 1 per cent. necessary to offset the cost of the improved lighting conditions.*

Conclusions.

Amongst recommendations for improved lighting the following may be mentioned:—

(1) Totally enclosed units should be provided furnishing an illumination, when first installed, of 10 foot-candles everywhere on an horizontal working plane 45 inches above the floor.

(2) Lighting units in the general workrooms should have a brightness not exceeding 2·5 candles per square inch (and in offices not more than 2 candles per square inch) when used with a source emitting 3,100 lumens. The units should have an output of at least 80 per cent. of the light obtained from the clear lamp.

(3) Wire screening should not be used for the back of separation cases on account of its bad effect on the eyes; it should be replaced by a continuous surface or by strips of wood 2 in. wide and ¼ in. apart, so as to allow ventilation.

(4) Shifts should be so arranged that a maximum of work is done by daylight illumination.

(5) The eyes of post office workers should be annually examined by an eye specialist and any defects recorded and corrected.

(6) In order to maintain the desired illumination of 10 foot-candles, about 2 watts per square foot of floor area will be necessary.

(7) The relation between separation cases, tables and desks to the light should be such that no shadows fall upon the working plane. For separation cases lights should be 1 foot in front of the vertical plane of the cases.

(8) The care of the lighting should be placed in the hands of one man, who should make a daily round of the building and replace all burnt-out lamps and broken fittings. He should arrange for lighting units to be cleaned once a week, or as often as necessary, and see that walls and ceilings are kept in satisfactory condition. He should make measurements with a foot-candle meter once a month in order to see that uniformity and constancy of illumination are maintained.

(9) The switches should be under the control of the foreman, and should be so arranged that the number of lights turned on and the order in which they are turned on would be such as to give the necessary illumination, while at the same time economizing the light.

(In a final note suggestions for methods of installing lighting units, in order to obtain the desired illumination, are made.)

Methods of Testing the Effects of Higher Illumination

IN recent discussions on the results of better illumination it has often been pointed out that some means of testing the actual effect on acuteness of vision, speed of perception, etc., is needed. In a paper before the Illuminating Engineering Society in Germany, Dr. Walter Ruffer recently described a series of devices used in experiments conducted in the Osram G.m.b.H. laboratory in Berlin.

The first of these, an apparatus for testing *acuteness of vision*, consisted of a white screen, against which a number of very fine tungsten filaments were viewed. The screen received the available illumination, and the number of filaments that could be seen at a specified distance was taken as an indication of acuteness of vision. Another piece of apparatus, designed to test *power of attention*, involved two operations—the sorting of a series of glass tubes of varying length in three boxes, and the simultaneous attention to two sand-glasses, which had to be inverted whenever the sand had completely run through. Here freedom from errors in both cases was the index.

Tests of *speed of vision* and *accuracy of work* were conducted by means of another device, the observer being asked to arrange small metal rods over divisions marked in the field of view. *Speed of action* was tested by means of an electro-magnet holding an armature; the observer was asked to open a circuit and allow the armature to drop, and then replace it and repeat the operation. *Delicacy of touch* was tested by operations involving the threading of 60 beads on string. *Steadiness of hand* was observed by a device for passing metal strip through an aperture without touching the edges of a slit, any failure to do so being automatically recorded.

Other operations included the sorting into position of cards bearing series of letters and numbers (*test of concentration*), perception of letters on cards exhibited only for a short interval of time (*rapidity of perception*), and ability to carry out simultaneously two distinct operations with the two hands.

The experiments were conducted on ten different operators taken from different departments of the works. The initial illumination was 75 lux,* the value normally provided in the room. Afterwards tests with 1, 3, 5, 10, 25, 50, 100, 10, 300, 50, 600, and 100 lux were made (the lower values being arranged at intervals in order to examine the effect of a return to diminished light).

From the results, which are assembled in tabular form, it appears that in the case of most of these operations the higher illuminations had a material influence. Diagrams for tests of attention and sorting of cards show an almost continual rise in efficiency up to between 50 and 100 lux, after which the increase in the effect

* As a rough approximation one lux can be regarded as about equivalent to one-tenth foot-candle.

is less marked, though there are still indications of improvement. It is evident that in practically all cases the efficiency for illuminations below 10 lux is very much reduced. Taking the efficiency at 25 lux as 100, the values for 1 lux average 26·6, 38·3, and 48·4 for three groups of operations. For illuminations above 25 lux the change is naturally not so great, but is still perceptible. Thus, at 100 lux the corresponding values are 198, 120 and 108 respectively; at 300 lux the values (228·3, 120·7, and 114·8) show only a relatively small increase, whilst at 600 lux the improvement is still less evident.

The tests, therefore, seem to confirm the general impression that when the illumination falls below one foot-candle (approximately 10 lux) the loss in efficiency is very marked, whilst for an increase in illumination up to 5-10 the gain in efficiency is very considerable; for illuminations above 10 foot-candles the gain in efficiency is more doubtful, though it is quite possible that in the case of certain forms of work these exceptionally high illuminations may be economically justified. The conclusion drawn by Dr. Ruffer is that the most favourable range of illumination lies between 100 and 200 lux (say 10 to 20 foot-candles).

Some interesting confirmatory tests made by Dr. Bloch are mentioned. In these experiments the workers (one man and four women) were asked to thread a needle with white cotton. The time necessary for this operation with various illuminations was noted. Here again a very marked increase in speed was observed when the illumination was increased from 1 to 30 lux; between 30 and 300 lux the improvement was relatively less, but still appreciable, namely, about 10 per cent.

Naturally these results should be regarded merely as experimental, and they need to be confirmed by prolonged researches with a larger number of operators. But the initiation of such a series of experiments, designed to test different qualities, is an enterprising step, and it would be interesting to have confirmation by similar experiments in this country. In the concluding portion of his paper Dr. Ruffer quotes the experiments conducted by the United States Public Health Service in connection with post-office operators, which are summarized elsewhere in this issue.

Advertising Street Lighting Equipment

In connection with the new lighting installation at Indianopolis, in the United States, an enterprising effort is being made to interest the public and explain the nature of the improvements. The Merchants Heat and Light Company is displaying in a prominent window large pictures of the ornamental standards to replace the present low candle-power units, which it is claimed will increase the total illumination of the streets by more than 1,000 per cent. *The Electrical World*, in commenting on this step, reproduces a view of the window. When new lighting schemes of public lighting are introduced in this country, it would be an advantage if local authorities, supply undertakings or suppliers of lighting equipment would do more to draw public attention to the improvements. Not infrequently such improvements are introduced unobtrusively and scarcely noticed by the public. If the benefits of the advances were impressed on them by some educational campaign, this would help to create public opinion in favour of better street lighting, and it is on public appreciation of these benefits that advances ultimately depend.

Neon Lamps

The neon lamps, especially those capable of being inserted direct on the ordinary supply voltage continue to attract notice. On page 90 we refer to some researches in the United States. We notice in *L'Elettrotecnica*, a discussion by Sig. A. Fauconnier of the principles of luminescence involved and the selection of gases and electrodes. The contribution also refers to the arc between tungsten electrodes, of which several apparently novel forms are shown. Evidently lighting is being studied closely in Italy.

Astronomical and Physical Photometry

IN a paper recently presented before the Illuminating Engineering Society in the United States, Professor Ch. Fabry dealt in an interesting way with a subject somewhat outside the ordinary range of photometry—the determination of magnitude and brightness of stars and other astronomical data.

"Astronomical photometry" is of ancient date. Apparently some of the earliest known work was done by Hipparchus, who lived about 150 B.C., and who divided stars into six arbitrary classes according to brightness. Much later Bouguer, whom Mr. Trotter has called "the father of photometry," in his book issued in 1729, *Essai sur la graduation de la lumière*, made comparisons between the light of the sun and the moon with a tallow candle. (The difference in colour was described by Bouguer as "somewhat embarrassing"—a term which is probably mild compared with those used by some students to-day when asked to compare a carbon lamp with an arc lamp!)

Bouguer does not appear to have attempted the measurement of the brightness of stars. But such measurements are now a familar feature in astronomical work. However, in the case of stars we have to deal with point sources without any appreciable angular diameter, and we receive a flux of light too small to produce any appreciable illumination on a diffusing screen. Hence, instead of the ordinary balance of brightness of two closely adjacent luminous surfaces, we have to judge the brightness of two separated bright points; thus the degree of accuracy is much less than that attainable in ordinary photometric tests. "Magnitude" involves a constant ratio between stars of successive rating and is thus directly proportional to the logarithm of intensity.

According to various tests the full illumination of the sun is about 100,000 lux.* Its brightness can be computed average as about 1,400 candles per sq. mm. But the brightness is not uniform and probably the central part attains 2,000 candles per sq. mm. The light yielded by stars is of course far less than that derived from the moon. Still such light is appreciable. A star of the twenty-first magnitude, the feeblest that can be detected with the most powerful telescope, would give an illumination equivalent to one candle-power at a distance of 10,000 kilometres. (A distance not far removed from the diameter of this earth.)

In other astronomical work one deals with very low brightness. To some people it may come as a surprise to hear that the night-sky has any appreciable brightness. City dwellers, accustomed to bright artificial lighting and motor headlights, rarely have an opportunity of judging this. But in fact the night-sky is not dark. One's hand silhouetted against it appears distinctly darker; and it even yields an appreciable illumination, sufficient to enable one to make one's way along an unlighted road at night. According to Professor Fabry the brightness of the night-sky is about 2×10^{-8} lamberts. This is about 1/500th of the degree of brightness furnished by average phosphorescent materials. The illumination derived from the night-sky has also been computed. It is equivalent to about 2×10^{-4} lux. We know little of the cause of the luminosity of the actual sky, but the stars visible with the largest telescope are only responsible for about one-third of this night-illumination. Every square degree of sky gives the same illumination as a star of the fifth magnitude.

Even more striking is the fact that such a small brightness as that of the night-sky can cause glare. Yet this brightness is sufficient to prevent astronomers from seeing the smallest stars. The visibility with the naked eye is limited to stars of the sixth magnitude. Why is this? Because the others are too feeble to produce any appreciable impression on the retina of the eye? Not at all. It is because the glare from the night-sky prevents these relatively feeble stars being visible.

* One lux may be taken as roughly equivalent to one-tenth foot-candle.

The Physical and Biological Action of Light

I.—Physical Characteristics of Sunlight.

An address recently delivered by Dr. T. Garfield Evans before the Cardiff Medical Society on the above subject serves as a striking illustration of the value of correlation of physical and physiological facts.

The early part of the address consisted in a summary of the physics of light. The author recalled Newton's discovery of the spectrum, but remarked that Newton died without knowing that there was an extensive series of invisible radiations differing only in wavelength and frequency from visible light. The existence of the infra-red region was discovered by Herschel in 1800. Ampere, in 1835, first showed that these heat-rays were of the same nature as light-rays, that they were both due to waves in the same medium, and only differed in wavelength.

Transparency of Different Media to Ultra-Violet Rays.—Radiation, however, is much affected by the media through which it passes. Ordinary glass is opaque to wavelengths shorter than 340μ. Quartz is transparent up to 185μ. Fluorite is even more transparent, and by using this material Schumann extended the explored region from 200μ to 120μ. The limit of the solar spectrum has been found to be about 280μ, calculated at a height of 4,560 metres.

The energy in the solar spectrum may be considered to be about equally divided in the infra-red, visible and ultra-violet. Langley estimated that 60 per cent. of the total energy was in the infra-red region. The rate at which energy is delivered to the earth by the sun has been calculated to average 7,000 h.p. per acre, or 1·45 h.p. per square yard. The problem of utilizing this energy efficiently has, however, still to be solved.

Effect of the Earth's Atmosphere.—The lecturer next proceeded to give an account of the nature of the earth's atmosphere. The lower layers (the troposphere), which are mixed by wind currents and contain clouds, reach an average of about 11 kilometres in height. This section, it is believed, contains about three-quarters of the mass of the whole air-shell which surrounds the earth. Above this is the stratosphere, which is windless and cloudless and at a constant temperature. Here the gases of low specific gravity (hydrogen, helium, etc.) increase in amount.

Here, too, the air is ionized by the sun's ultra-violet rays, and the excess of these rays is filtered off, so that the spectrum of light, as it actually reaches us, contains a comparatively small proportion of energy of this kind. It is also calculated that water vapour retains not less than one-quarter of the sun's energy which reaches the atmosphere.

The sky owes its brightness to the scattering of solar rays by water vapour and particles of dust and air. The moon only reflects one two-millionth of the sun's rays. The sun is the one essential source of warmth. The temperature of the atmosphere decreases with height on an average 1° F. for every 300 ft. Air is heated by the absorption of the sun's rays, by dust and moisture present in the lower strata, and by contact with the heated surface of the earth.

Sunlight, as received in the mountains, is richer in ultra-violet light than rays arriving in the plains, besides being more highly luminous. On clear days about 75 per cent. of the sun's energy which reaches the earth's atmosphere arrives at an altitude of 1,800 metres, but only 50 per cent. of this radiation arrives at sea-level. In a smoky city this amount may be reduced to one-third or less. Even when the sun is highest the proportion of ultra-violet light in the spectrum of light from the blue sky is 15 per cent. greater than in the case of direct sunlight—so rich in ultra-violet is the diffused light of the blue sky.

Some Biological Actions of Light.

All the above data are of extreme interest in relation to the effects of light on the human body. With the exception of atomic energy, made known to us in the case of radio-active elements of the earth, the sun is the prime source of energy. Theory now recognizes that every chemical action is started by radiant energy. The living animal receives stored solar energy in the form of food, and is excited by radiant energy.

Penetration Effect of Pigment.—One important respect in which light of various wavelengths differ is in degree of *penetration.* Thus, while about 20 per cent. of red-yellow rays pass through a rabbit's ear, only 1 per cent. of the blue-violet rays do so, and none of the ultra-violet. Thin films of skin formed from gelatine, collodion, etc., will protect bacteria and infusoria from the lethal action of ultra-violet rays.

Another element affecting penetration by rays is pigment. Melanin, the brown pigment natural to the skin of the negro, can be isolated from ox-eyes, and forms a brownish suspension in water, which absorbs all except the red end of the spectrum. Such a suspension, placed in the palm of the hand, protects the skin from the heat of the sun, concentrated by a burning glass. Owing to this pigment the black man can have a thinner skin, thus loses heat more easily and perspires more easily than the white man. The prime function of pigment of the skin, produced by exposure to ultra-violet rays, is to act as a screen against the effect of excessive light and its conversion into heat.

"*Light-Sensitizers.*"—Another highly interesting point is the existence of "sensitizers." Chlorophyll is a sensitizer converting light into heat, and also acts as a protective screen. The red blood corpuscles act as a screen and converter of visible rays into heat, which, warming the subcutaneous blood, is believed to have an important influence on immunizing power. Hæmato-porphyrin, the iron-free derivative of hæmoglobin, is a remarkable sensitizer. A small quantity of this injected into white guinea-pigs renders them so sensitive that they die from exposure to light. Major Betz, after injecting a small quantity into himself, made himself ill by exposure to very moderate light, and remained hyper-sensitive for weeks. Eosin sensitizes animals to light. The feeding of cattle on buckwheat makes them so sensitive to light that sores develop on unprotected parts—exposed unpigmented parts. Deficiency of protein in the diet of people half-starved during the war produced similar effects. The pigmented skin of a person habitually exposed to sunlight is much more resistant to infection; only with difficulty can smallpox vaccine be made to "take" over a pigmented area. Febrile rashes, such as chicken-pox, affect least the well-pigmented parts. Sensitization to visible rays also prolongs the depth to which light can act. Indeed, sensitization to light opens up a new field, hardly yet explored, in therapeutics.

Sunstroke and Heatstroke.—Sunstroke is produced by local heating of the brain, as well as the body generally. Heatstroke is produced by general heating of the body. People acclimatized to work in a hot place acquire self-protection by increased capacity to perspire; thus they may be able to sweat 3 lbs. per hour as compared with 1 lb. in the case of an unacclimatized person. "Erythema," the inflammation of the skin following exposure to strong ultra-violet rays, can be intensified by blowing a warm current of air on the part treated, or conversely reduced by a cold wind. Similarly the lethal action of these rays on micro-organisms is accentuated by heat, and diminished by reduced temperature.

Relation between Diet and Exposure to Light.—Animals and men receiving a well-chosen diet rich in vitamines can live for long periods in the absence of sunlight (e.g., take the case of night-workers, pit-ponies, etc.). Rabbits have been kept in obscurity for months without any profound alteration of their vital functions. On the other hand, when diet is deficient exposure to sunlight can ward off or delay the evil effects. Young children fed on a deficient diet are protected from the development of rickets by short daily exposure to the sun. Confirmatory data are furnished by the concentration of calcium and inorganic phosphorus in the blood following exposure to light, which are said to be identical with those resulting from the administration of cod liver oil! Apparently an exposure of two minutes a day to the ultra-violet light of the mercury vapour lamp one yard away, or fifteen minutes to direct sunlight, is sufficient protection. Ordinary window glass tends to filter out the protective rays; hence rickets arises in tenement dwellings from deficient diet and want of sunlight, whilst there is none in the squalid cabins of the Hebrides, where children get fish oil and live largely out of doors. It is recognized that rickets is a disease of darkness and can be cured by sun-baths. The most active rays are those just about or below 300μ—in the same region as the rays in sunlight produce pigmentation of the skin. Pigmentation, by protecting the skin from these rays, hinders their action. Hence, negro babies in New York are found to be more susceptible to rickets than white babies. These experiments bring out in a wonderful way the close relation between the effect of light and the health and vigour of human beings.

A Review of Carbide

A meeting of the British Acetylene and Welding Association, preceded by an informal dinner, was held at the Old Colony Club (Aldwych House) on March 16th. Mr. Charles J. Quirk (President) took the chair, and a paper on "A Review of Carbide" was read by Mr. C. Coulson-Smith.

After explaining the process by which acetylene is derived from carbide, the author discussed the manufacture of this material in considerable detail. Special importance was attached to the fuel used in the furnace, good anthracite being the most suitable. In the early stages of carbide manufacture the formation of a haze when the gas was burned was traced to the presence of phosphates in the lime and carbon. These impurities should now be absent.

Mr. Coulson-Smith discussed the selection of carbide by inspection, though he agreed that a chemical analysis was desirable. Generally speaking, however, a carbide would be found to be of good quality (1) if the colour was grey, (2) if the material was fairly difficult to break, and (3) if a fractured piece showed crystalline structure with bluish streaks. The lecturer also criticized the usual method of sampling, lots being selected from the top, middle and bottom of the drum. He believed that a proper analysis would be more readily made if the material was crushed and samples taken by both buyer and seller were then mixed and analysed.

The process of purification was discussed in some detail, and the possibilities of making use of residual lime considered (the lecturer's enthusiasm leading him to break into verse in this connection!). In conclusion, Mr. Coulson-Smith raised the vexed question whether carbide was to be regarded as a synthetic organic compound or as inorganic.

In the ensuing discussion Mr. W. J. A. Butterfield, Mr. Leon Gaster, Mr. C. S. Milne, Mr. A. Stephenson, Mr. A. E. Shorter, Mr. R. Hoddle and Mr. W. Hill took part.

The Chairman, in winding up the discussion, alluded to the great difficulties experienced during the war when manufacturers were asked to produce carbide from very inferior fuel. Some progress had since been made, but they had not got back completely to the pre-war conditions.

A New Form of Lamp for Automobile Headlights and Projecting Apparatus

As is well known, the successful operation of electric lamps in automobile headlights involves accurate focusing of the filament, and difficulties are introduced by slight variations in the position of the filament in different lamps. It would be a great advantage to have a form of lamp such that accurate focusing was guaranteed, and which was strictly interchangeable.

M. A. Marsat, in the *Revue Generale de l'Electricité*, describes a new device introduced by a French firm, which is believed to meet this requirement. The fundamental idea consists in mounting the lamp on to a spherical metal base, which rests lightly within a metal cylinder. The lamp has thus four degrees of freedom, and by gently rocking it the position corresponding with accurate centring of the filament on the axis of the cylinder can be found. This position is determined by a special optical device, comprising two mirrors at right angles, enabling the operator to view two images of the filament, seen from directions at right angles. The lamp is then adjusted so that these images fall exactly over cross-lines in the field of view, and is then soldered in position. It is suggested that the device will prove useful, not only for motor-car headlights, but in the case of lamps applied in various forms of projecting apparatus, including lighthouses and beacons.

Fluorescence and Phosphorescence

In a contribution to the *General Electric Review* (U.S.A.), Mr. W. S. Andrews, who is a recognized authority on this subject, points out that no hard and fast line can be drawn between "fluorescence," which is visible only when material is being exposed to some excitant, and "phosphorescence," which continues after the stimulus has ceased. Any material which fluoresces must naturally exhibit phosphorescence during the period when it returns to darkness, though the duration of the effect may be short. It is interesting to note that the source of excitation may be an important factor. Thus calcium tungstate, energized by ultra-violet light from a disruptive discharge, shows pale blue fluorescence but no appreciable phosphorescence; but if excited by X-rays the phosphorescence is very marked.

According to Mr. Andrews, emission of light takes place only when the electrons of a substance, instead of following their normal orbits, are put out of step; the natural tendency is for them to resume their normal path as quickly as possible, but during the period of settlement we may see the phenomenon of phosphorescence. Mr. Andrews then discusses in turn the various processes, other than incandescence, which lead to emission of light (e.g., "photo-luminescence," due to exposure to light, "cathodo-luminescence" due to effects of cathode rays, "electro-luminescence" caused by electrical excitation, etc.). Of these, electro-luminescence, as revealed in various gaseous illuminants, has the greatest practical importance. In other directions there does not seem much promise of considerable practical advances at present, though the experiments of Dr. Newton Harvey, of Princetown University, who has studied the processes causing phosphorescence of certain marine organisms, and has shown that the light-giving material can be isolated and preserved, are highly suggestive.

POPULAR & TRADE SECTION

COMPRISING

Installation Topics—Hygiene and Safety—Data for Contractors—Hints to Consumers

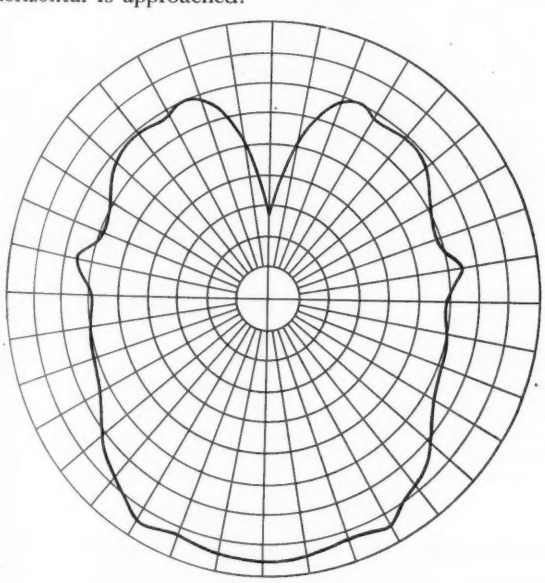
Some Notes on Electric Lamps

No. 4

By W. J. JONES, B.Sc., A.M.I.E.E.

(E.L.M.A. Lighting Service Bureau).

REFERENCE was made in the February issue of this Journal to the introduction of "white" gas-filled lamps and their intrinsic brilliancy compared with the standard clear lamp. In addition to the reduction in brightness, making it less a source of annoyance from glare, the fact that the whole bulb becomes the radiator of luminous energy in the place of the spiralized filament, considerably modifies the shape of the polar curve of distribution of the light. Fig. 1 shows the polar curve of a standard 100-watt lamp, and it will be observed that the greatest intensity of light is in a downward direction, gradually reducing in amount as the horizontal is approached.



POLAR CURVE OF CLEAR GASFILLED LAMP

FIG. 1

This is as one would be led to expect with a ring type of filament, for a maximum amount of filament is seen in a vertical direction and least in the horizontal (see plan and side view of filament, Fig. 2). The polar curve of a white lamp, given in Fig. 3, indicates that the position of maximum candle-power is in a horizontal direction, and this fact has been turned to good account in their use for street lighting purposes, where a high proportion of light is required laterally.

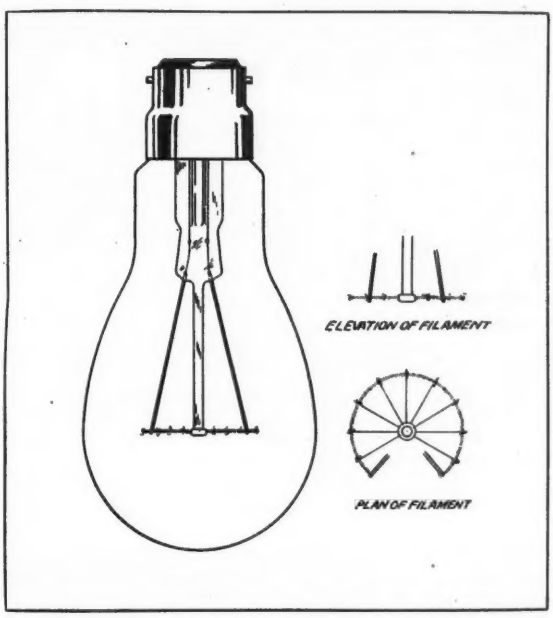
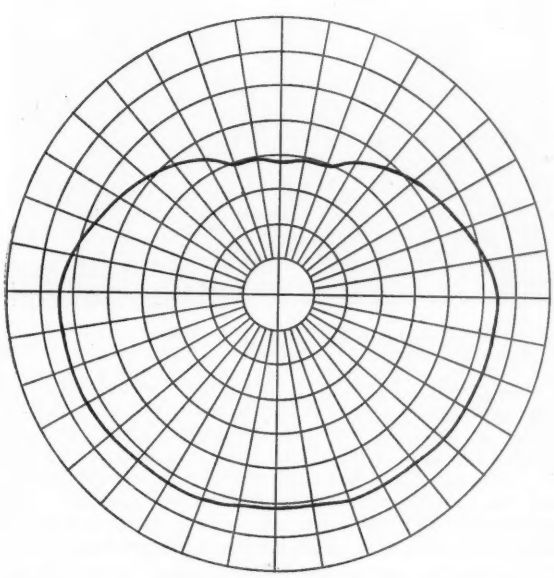


FIG. 2.—Showing plan and side view of filament.



POLAR CURVE OF WHITE GASFILLED LAMP

FIG. 3.

The difference in the nature of these polar curves naturally brings about a difference in their spherical reduction factors. If the total luminous flux of a lamp is required and the only information given is the horizontal candle-power, then the flux can be determined quite readily by means of the ratio called the spherical reduction factor. It is defined as the ratio of mean spherical candle-power to mean horizontal candle-power, and in the case of the ordinary vacuum lamp, with an up-and-down winding, is less than unity, approximately 0·78. When, however, considering a gasfilled lamp with a ring-type filament, since the horizontal candle-power is less than that in other directions, the reduction factor becomes greater than unity; for small lamps it varies between 1·0 and 1·2. The white gasfilled lamp, however, brings about a reversal of these conditions, and it will be found that the reduction factor is very similar to that of the ordinary standard vacuum lamp. In the case of a 100-watt lamp it has been found to be approximately 0·90.

Some Notes on Electric Lighting in the Home

ILLUMINATING engineers often find that light sources are so used as to produce harmful glare, which not only impairs one's ability to see clearly, but also produces permanently disastrous results to eyesight. The general lack of the application of correct principles of illumination is particularly noticeable in the lighting of our homes. So many people regard electric lighting merely from its utilitarian purpose alone—namely, that of light which can be switched on at will—but they fail to appreciate how much lighting can contribute to the beauty and comfort of the home. Modern lamps and fittings definitely create at atmosphere of comfort, and the recent introduction of lamps which are tinted and coloured provides almost endless means of enhancing the decorations of the room, and of emphasizing details which were previously obscure.

Fig. 1 illustrates clearly some of the delightful effects which can be obtained by the intelligent use of light in

FIG. 1.—Illustrating use of central fitting to illuminate table. (The old-fashioned 3-light pendant, by contrast, shows what should *not* be done.)

a living-room. It will be noticed that the central fitting is designed to effectively illuminate the table, and in this particular case can also provide some general illumination for the room itself, since lamps are arranged within the corona to illuminate the ceiling. The wall brackets and the ornamental table decoration indicate some further uses of light in the home, and stand out in contrast with the old-fashioned three-light pendant.

Fig. 2 is yet another example in which light may add materially to the effectiveness of the decorations of a room. In this instance two alabaster bowls on wall brackets are equipped with orange-sprayed gasfilled lamps and create an atmosphere of warmth. It will be noticed that there is a complete absence of pendants from the ceiling, in what can be considered suggested

FIG. 2.—Novel ornamental lighting by alabaster bowls on wall brackets. (The 3-light fitting again appears as an example of obsolete methods.)

good lighting of this room. Again, the old-fashioned three-light pendant appears incongruous.

One often finds that the lighting of the bedroom is specially atrocious, for not only is it difficult to see clearly in the mirror, but at the same time images are distorted by harsh and objectionable shadows. These are the kind of effects that would be obtained by the single pendant, as illustrated in Fig. 3. At the same time there are clearly shown a number of excellent means of

FIG. 3.—The single pendant would be quite unsuitable for the lighting of a bedroom. Alternative modern methods are illustrated by the central bowl fitting, the brackets beside dressing table, and the fittings at the bedside.

providing effective illumination in the bedroom. The brackets attached to the dressing-table provide effective lighting free from shadows, the central bowl fitting gives a general soft and diffused illumination throughout the whole room, while the lamp standard and the fitting at the head of the bed permit further comfort.

Good Lighting and Parental Responsibility

We have always believed that the general improvement in illumination is a boon to mankind. A writer in one of the Sunday papers, however, has discovered an objection. He argues that the new generation spend less of their time at home chiefly because the streets and places of entertainment are so much better lighted than in the past; and that this better lighting is consequently detrimental to home-life! This is surely a singular view to take. Safer lighting of the streets, better illumination of theatres, kinemas, restaurants, and places of entertainment benefit young and old alike. Meantime parents should be mindful of their own responsibility to provide good lighting in the home. If the rooms are ill-lighted in comparison with places of entertainment this is an obvious inducement to children to wander.

Electric Lamp Manufacturers' Association of Great Britain Ltd.

Second Illumination Design Course

IT was recently reported that a large number of engineers from supply authorities came from all parts of the country to attend the Illumination Design Course arranged by the Electric Lamp Manufacturers' Association. These representatives attended for four whole days in order to be made *au fait* with the most recent advancements in the science of illumination. Since then a number of letters of appreciation have been received stating how useful the information which was given has already proved, and that every day the knowledge gained is being put into practice.

The whole of the electrical industry is intimately concerned with lighting and its correct application, for wrong methods of application are so blatant that they reflect upon the industry as a whole. It is in order to rectify this position that the Illumination Design Courses are being given, and below are a few extracts from letters received from people who have already attended:—

C. G. Le Feuvre, The North Metropolitan Electric Supply Co. (Harpenden):

"I should like you to know how much I have appreciated the opportunity of learning a little more about a subject in which I have always been interested, and I have no doubt that the wonderful enthusiasm shown by the various speakers must react on the members of their audience to their mutual advantage and to the betterment of lighting conditions for the community in general."

J. F. Griffiths, South London Electric Supply Corporation:

"I was fortunate in being able to attend the whole course and the information gained, I am sure, will be very valuable and useful both to my employers and myself, and will help me to carry out my duties 'on the road' in a more efficient manner than heretofore."

Alec G. Cheal, The Crowborough District Gas and Electricity Co.:

"In connection with the Illumination Design Course and Discussion held at the E.L.M.A. Lecture and Demonstration Hall last week, and attended by my assistant, Mr. P. G. Hobbs, we wish to place on record our appreciation of your efforts to give the all important subject, 'Better Lighting,' the prominence it deserves. The very important data collected, the lucid explanations given by the various lecturers, the practical demonstration of each argument must convince those who attended that the lighting field is really waiting development. We are sure that such enthusiasm as is displayed by your personnel and the striking character of the literature available will, when broadcast to the general public, result in considerable increase of revenue to central stations throughout the country and at the same time give greater value and increased satisfaction to the consumer. Wishing the Lighting Service prosperity, popularity and success."

C. E. Allsopp, City of Bradford Electricity Department:

"We had a glorious time, there being plenty of food for the mind and the stomach, and there is little doubt that the food for the mind will have the more lasting effect, especially when the members of the industry generally have been raised to that altitude at which the efforts of the Lighting Bureau have placed us, and I hope that the good work will go on and on, and that the provinces will be looked after in order that we may all work together for the good of the industry."

Further Illumination Design Courses are being given on April 21-24 for electrical wholesalers and factors, and on May 12-15 for electrical contractors. Those who are desirous of attending either of the above courses are asked to write immediately to the E.L.M.A. Lighting Service Bureau, 15, Savoy Street, W.C.2, in order that a place shall be reserved for them.

This school hall is 40 feet 6 inches long by 30 feet 6 inches wide. Until recently it was lighted by six 2-light upright incandescent burners with central feed. Three No. 2 (medium bijou) size inverted mantles on superheater have now been substituted for each pair of upright burners, with the result that the gas consumption has been considerably reduced and the light at the same time increased. The original reflectors and consumers are retained. For school hall lighting these fittings are generally fixed at a height of 8 feet from the floor to under-side of shade.

School Lighting

THE artificial lighting of our schools is a subject which deserves close study on the part of all school authorities, for inadequate school lighting is undoubtedly one of the causes of deterioration not only of the vision but of the physical and mental capacities of children and adult students.

A child working by insufficient light instinctively bends in order to bring his eyes nearer the work. This habit of assuming a stooping attitude is bad for the figure of the child. The Medical Research Officer to the London County Council has pointed out, also, that light coming from the wrong direction and casting inconvenient shadows of the body causes children to assume a cramped, unnatural attitude, and may even lead to spinal curvature. Again, habitual work in a poor light may be detrimental to the general nervous system, for it increases the strain of work at a critical period in the child's development. A child who is short-sighted loses much of what goes on around him, and is often put down as stupid or inattentive. Thus poor lighting, by causing defective vision and impairing one of the channels by which information is received, also prejudices the brain development, and may therefore interfere with a child's education—a serious handicap in after-life.

There is one other strong argument that may be brought forward on behalf of good lighting in schools. The illumination should be good for the same reason that the schoolroom should be cheerful and clean—because it serves as an example to the children. If they find in the schoolroom makeshift and antiquated lighting they go out into life with a low standard in this respect, and so the evil is perpetuated. If, on the other hand, they find that every room they enter is carefully lighted, that the illumination is always sufficient, and that the lamps are properly shaded and kept clean, they in turn will try to secure the same conditions in their own homes. There is an intimate connection between cleanliness and good illumination. A badly-lighted, gloomy room naturally is not kept as clean as it should be, since the dust cannot be seen. Living in poorly lighted rooms also encourages neglect of personal cleanliness. One of the most important influences in the elementary schools to-day is the training of children in habits of cleanliness. We may be sure that a well-lighted room makes the task easier for the teacher in this respect; and that in a poorly-illuminated room the supervision of cleanliness will be less thorough.

The question may be asked, "What is meant by good lighting in a schoolroom?" A special committee composed of members of the Illuminating Engineering Society, the Association of Medical Officers in Schools, the Association of Teachers in Technical Institutions, and other kindred bodies, made exhaustive enquiries into prevailing conditions of lighting (both natural and artificial) and issued useful reports on the subject in 1913 and 1914.*

A few of the most important points on artificial lighting may therefore be mentioned.

In the first place there should be sufficient illumination on the desks where the children read. The Committee recommended that the illumination on each desk should be not less than two foot-candles. (By a "foot-candle" is meant the light received from a lamp of one candle-power one foot away. Two candles set up a foot away from a white surface would give approximately the illumination mentioned above.) A considerable number of tests were made in schools in London, and it was

* "Artificial Lighting in Schools," *Illuminating Engineer*, July, 1913; "Daylight Illumination in Schools," *Illuminating Engineer*, July, 1914.

ascertained that an illumination of this strength was quite practicable. Indeed, in view of the advances that have been made in gas lighting during the past ten years this value might now be increased with advantage. In a number of cities in the United States standards which specify a considerably higher order of illumination are now in use.

A point of special importance in connection with schoolroom lighting is the avoidance of glare from the sources of light. It is a common defect in schoolrooms for the bare source of light to be within range of vision of students when they are looking towards the blackboard. The Committee recommended that no lamps should come within the solid angle subtended at the eye by the blackboard and a space of two feet above it unless they are completely screened from the eye by a shade impervious to light. Another source of glare is the direct reflection of light from the polished surfaces of the desks or paper. It would be desirable for text books intended for the use of young children to be printed on matt paper that is sensibly free from prejudicial reflection of this kind.

In classrooms the lights should be so arranged that inconvenient shadows cast by the body on the desk should be avoided as far as possible. The use of light-tinted surroundings which serve to diffuse the light may be recommended with a view to softening the shadow. The ceilings should be white, and the walls and all woodwork above the dado should be light in tint.

Another detail which received the attention of the Committee was blackboard lighting. Whereas the minimum illumination suggested for reading purposes (namely, two foot-candles) might be enough in the case of a small classroom where white chalk is mainly used and no students are more than twenty feet away from the blackboard, a higher value would in general be necessary in the case of larger rooms, and on diagrams where it is customary to use coloured chalk. As the result of a series of experiments, the Committee were of the opinion that an illumination on the blackboard about 60 per cent. in excess of that prevailing in the rest of the room was desirable.

The valuable work of this Committee has already borne fruit, for the London County Council subsequently carried out experiments in order to discover the best kind of burner which could be adapted to existing gas fittings with a view to improving the lighting of their schools. Even distribution of light, adequate illumination, absence of glare and of shadows, and economy in fuel and maintenance costs were the main points considered. As a result the London County Council have already converted over a hundred of the gas lighting installations in their schools on lines indicated in the illustrations which accompany these notes.

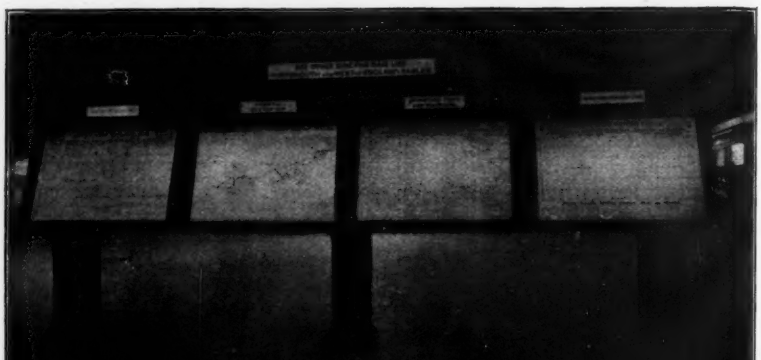
The example set by London has been followed in many provincial towns, and the gas lighting in many schools has within the last few years been brought up to a high standard of perfection.

In nearly all cases the gas burners used have been of the new superheated inverted incandescent type which gives 50 per cent. more light per cubic foot of gas burned than the ordinary low-pressure inverted incandescent gas burner. The mantles used on these burners are generally of " medium " size, as it has been found that the use of clusters of comparatively small mantles instead of a smaller number of larger mantles has resulted not only in greater efficiency but in a reduction of maintenance costs. School authorities should, wherever possible, place in the hands of the skilled men of their local gas undertaking the periodical inspection, adjustment and maintenance of the burners, a service which many gas undertakings now render on reasonable terms.

The preservation of the eyesight of the coming generation is a matter of national importance, and the good work that is being done in connection with school lighting by the Illuminating Engineering Society deserves emphatic recognition. As soon as circumstances permit, it is hoped that the Committee will resume its researches and in due course issue fresh reports. Meantime it is of interest to note that the matter has also been receiving attention in other countries, and that at the first Technical Congress of the International Illumination Commission, held in Paris some time ago, it was resolved to appoint an International Technical Subcommittee to deal with the whole subject.

This classroom was originally lighted by "C" upright incandescent gas burners. The fittings substituted are 3-light superheated cluster burners with No. 2 size mantles and 10 inch by 5 inch conical shades. The burners are fixed at a height of 7 feet 6 inches from floor to under-side of shade. The deep shade was adopted to ensure an absence of glare in the eyes of the teachers and pupils. The burners are made of heavy brass and cast aluminium in order to give long and satisfactory service. This classroom is 26 feet long by 25 feet 6 inches wide.

Illuminated Time Tables at Waterloo Station



A photograph, taken entirely by artificial light, showing the appearance of these time-tables which are mounted on special racks and illuminated from the inside.

This development is in line with the extending use of other illuminated devices at railway stations (e.g., for indicators on arrival and departure of trains, destination, etc.), and is considered to be a decided improvement over the usual method of relying on the general station lighting.

In view of the account of the visit of members of the Illuminating Engineering Society to Waterloo Station, described in our last issue, it occurred to us that many of our readers would be interested in the accompanying illustration, showing the illuminated time-tables, and which first appeared in *The Illuminating Engineer* several years ago.

The time-tables are pasted on sheets of glass and mounted on special racks, and are illuminated *from the inside*. The high brightness thus secured at once attracts attention to the time-tables. The method has also the great advantage that a person standing in front of the rack does not cast an inconvenient shadow, as is apt to happen when time-tables merely receive general illumination from the station lamps in the usual way. Further, it will be conceded that the order of illumination available from such lamps, necessarily mounted at a considerable height, is scarcely sufficient to enable the fine figures of time-tables to be read with comfort.

We understand that this device at Waterloo Station has proved a great success, and a second series of racks of this kind has recently been installed.

The Lighting of Tunnel Subways

The lighting of tunnel subways provides a special problem of considerable interest in these days of traffic congestion. Suggestions have recently been made for the driving of an additional tunnel under the Thames. The Blackwall and Rotherhithe Tunnels, completed respectively in 1908 and 1897, carry a considerable volume of traffic. Being completed so long ago, it is not unnatural that the lighting arrangements have little very striking or original about them.

Attention has been drawn to the subject by the plans made in the United States for the lighting of the twin-tubes now being driven under the Hudson River for a vehicular connection between Manhattan and New Jersey. The expected maximum capacity is 23,000 vehicles per day in each direction. Hence the method of lighting, discussed in a recent paper before the American Illuminating Engineering Society by Messrs. B. E. Shackleford and D. W. Atwater, is of special interest. Before attacking this problem the authors studied the conditions applying to the Rotherhithe and Blackwall Tunnels, the Elbe Tunnel in Hamburg, the Glasgow Harbour Tunnel, and others. Apparently, however, this information offered little guidance for the new scheme.

The plans for the lighting of the Hudson Tunnel have been developed with the aid of small models. The chief respect in which they differ from previous methods is the placing of the sources, screened by panels of diffusing glass, at the sides. The choice of glassware and position of units had to be studied with great care in order to secure uniformity of illumination, and the order of illumination aimed at, 1·5 to 2 foot-candles, is doubtless considerably higher than is to be found in most of the existing tunnel subways. Tests made outside have shown that driving is effected with ease under these conditions. The mounting of the units flush on the walls seems to be a good feature, enabling a clear view ahead, combined with absence of glare, to be obtained.

American Street Lighting Tests

Professor F. C. Caldwell contributes to the Transactions of the American Illuminating Engineering Society an account of the special tests of street lighting made in Columbus, Ohio. Several firms were invited to install systems of lighting of four types involving consumptions of 1¼ watts per foot for residence streets, 2½ watts per foot for boulevards, 6 to 8 watts per foot for general business streets, and 16 watts per foot for important "white way" thoroughfares. Tests of illumination showed average illuminations of 0·075, 0·23, 0·34, and 1·2 foot-candles with the four methods. The Committee preferred a spacing of 129 ft. to 234 ft., as the latter was liable to give rise to glare at certain angles. As regards the type of diffusing glassware, apparently there was some preference for the "urn" as compared with the lantern type. The old 12½-foot standards were increased in height by a 3-ft. extension. The question whether "refractors," in preference to ordinary diffusing globes, should be installed is still under consideration.

The discussion revealed a general recognition that tests of illumination require to be supplemented by inspection of "visibility," absence of glare, artistic appearance, etc. In America there is an increasing tendency to allot a considerable proportion of the available light to the illumination of faces of buildings lining the street. Prof. Ch. Fabry, who joined in the discussion, mentioned, however, that in Paris the view is still held that practically all the light should be concentrated on the roadway. Notwithstanding the fact that Paris is known as the "City of Light," it is not usual for the faces of buildings to be highly illuminated, and generally speaking the façades are left in comparative obscurity. It was also admitted that whilst many of the main streets of Paris are as well lighted as those in any modern city, some of the side-streets are still inadequately illuminated.

An Artificially-Lighted Covered Lawn Tennis Court

The adjacent illustration shows another artificially lighted lawn tennis court—in this case one under cover. This court is situated at the Moray Park, Glasgow. It is stated that the photograph, which appeared in the *Osram Bulletin*, was taken entirely by the artificial light provided. It will be noted that the usual method of installing lamps in special reflectors at the sides of the court is adopted.

Covered Tennis Courts, Moray Park, Glasgow.

One of the chief problems in lighting a tennis court is to avoid glare in the eyes of players from the light-sources, and the problem is rendered specially difficult by the fact that the eyes of players are necessarily directed upwards in following the flight of the ball. When lamps are placed at the sides of the court, and shielded by reflectors in the manner shown, the likelihood of the source coming within the range of vision is reduced to a minimum. In this case an additional good feature was the use of 350-watt "White Osram" lamps. The diffusing coating applied to the bulb is not only valuable in still further diminishing possibility of glare, but also useful in producing soft shadows. The results appear to have been very satisfactory, and it is stated that the flight of the ball can be followed with ease and comfort.

Public Lighting in St. Martin's Lane, London

The tendency towards higher illuminations in street lighting is illustrated by recent improvements made in the vicinity of Charing Cross, where gasfilled lamps in specially designed lanterns have been freely installed.

The two illustrations, furnished by the General Electric Co., Ltd., picture the appearance of St. Martin's Lane. It is stated that the photographs are untouched and were taken on the same day, at midday by daylight and at midnight by artificial light. In this case 1,500-watt gasfilled lamps in "Wembley" lanterns were employed. It is not so very long since the use of incandescent lamps of such high consumption would have appeared quite impracticable; in the future it is possible that even more powerful lamps may be used.

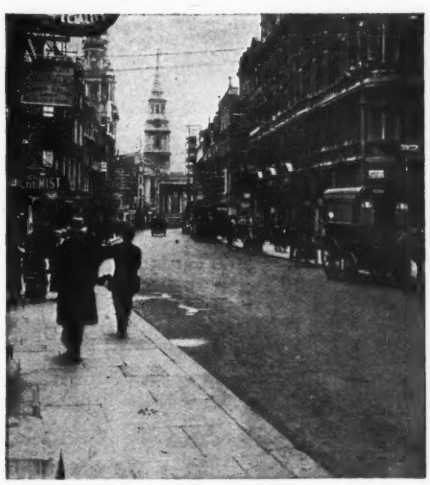


FIG. 1.—St. Martin's Lane, midday.

Holophane Street Lighting

A recent issue of "Holophane Illumination" is devoted entirely to street lighting. The latter part of the booklet contains illustrations of Holophane installations in many different towns and cities, and a description of the "2-way" and "4-way" refractors, the latter being specially suitable for use at the junction of two roads crossing, so as to give a powerful beam down each.

In the introduction a strong plea for good public lighting is made in the interests of safety of traffic. It is pointed out that during the last ten years the volume of motor traffic has increased by leaps and bounds. Municipal authorities have a responsibility for the provision of street lighting such as will ensure the safety of the public. In saving life and limb alone, efficient public lighting—which in any case forms only a small proportion of the total expenditure—pays its way. It is stated that in Glasgow the cost of lighting is only about 5s. per head of population, and this is only 10 per cent. of the cost of maintenance of surfaces of roads.

Apart from the requirements of streets in cities, the problem of providing suitable illumination for arterial roads, intended to carry fast motor vehicles journeying between cities or relieve congestion of traffic, also requires attention. Such arterial roads can only completely fulfil the purposes for which they were designed (and for which large sums of money have been allotted by the Road Board) if they are efficiently lighted.

Another statistical article further emphasizes the relation between street lighting and safety. There is also a contribution by Mr. Arthur J. Sweet on "Street Lighting as a Science," and a note by a City Lighting Engineer on difficulties encountered in street lighting. Some of these difficulties arise through the new method of road making, which are bottomed with reinforced concrete, and frequently present a dark-coloured surface which reflects little light.

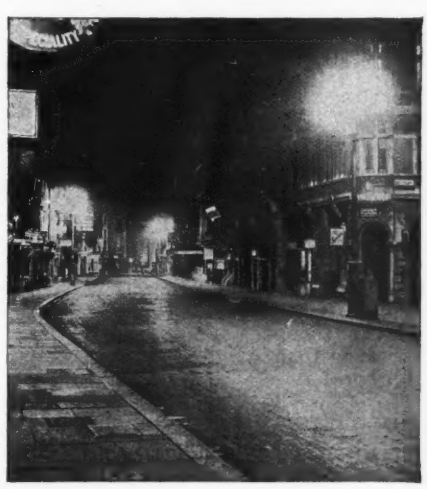
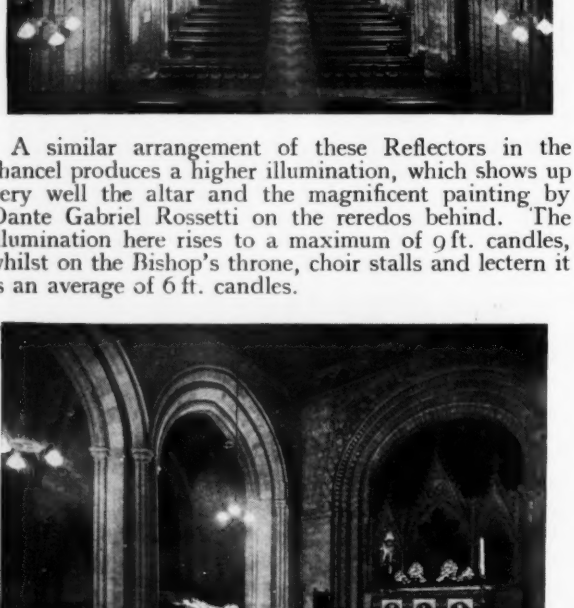


FIG. 2.—St. Martin's Lane, midnight (same day.)

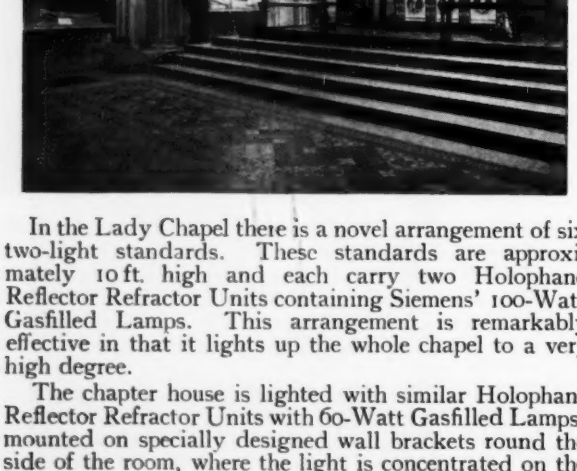
The Lighting of Llandaff Cathedral

AN interesting electrical installation has recently been carried out in Llandaff Cathedral, Cardiff, which is remarkably in keeping with the architecture and character of the building, and a good standard of finish appears to be generally arrived at.

The lighting installation consists of groups of three Holophane Reflector Refractor Units mounted on specially designed metal work, each fitting taking a 150-watt Siemens' Gasfilled Lamp. They are spaced in two rows down the cathedral, the rows being 35 ft. apart and fittings 16 ft. spacing and 16 ft. high, which gives a resultant illumination varying between 3½ and 7 foot candles. By this arrangement, the whole body of the cathedral is uniformly illuminated and an entire absence of glare is obtained.



A similar arrangement of these Reflectors in the chancel produces a higher illumination, which shows up very well the altar and the magnificent painting by Dante Gabriel Rossetti on the reredos behind. The illumination here rises to a maximum of 9 ft. candles, whilst on the Bishop's throne, choir stalls and lectern it is an average of 6 ft. candles.



In the Lady Chapel there is a novel arrangement of six two-light standards. These standards are approximately 10 ft. high and each carry two Holophane Reflector Refractor Units containing Siemens' 100-Watt Gasfilled Lamps. This arrangement is remarkably effective in that it lights up the whole chapel to a very high degree.

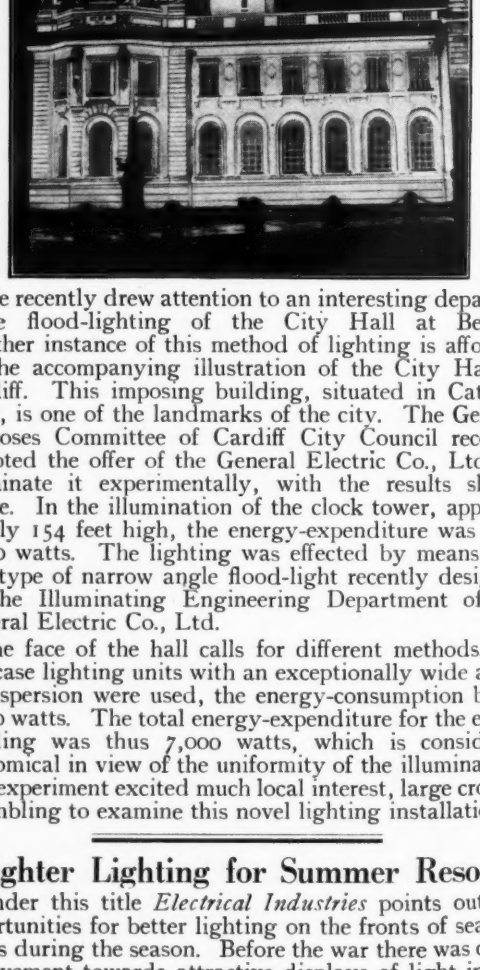
The chapter house is lighted with similar Holophane Reflector Refractor Units with 60-Watt Gasfilled Lamps, mounted on specially designed wall brackets round the side of the room, where the light is concentrated on the bookcases.

Llandaff Cathedral, which was restored in the early years of last century, is one of the oldest cathedrals in the country, and this installation, which was designed and carried out by Messrs. Haddrill, Hutchison & Co., Ltd., Electrical Engineers and Contractors, 112, Bute Street, Cardiff, shows their forethought and consideration of the architectural design. The whole installation harmonizes very well with the character of the building.

The consulting engineers were Messrs. Wm. Angus Scott & Partners, Cardiff.

The cathedral is lighted throughout with Siemens' lamps supplied by Messrs. Siemens & English Electric Lamp Co., Ltd., London and Cardiff.

Flood-Lighting of the City Hall, Cardiff



We recently drew attention to an interesting departure —the flood-lighting of the City Hall at Belfast. Another instance of this method of lighting is afforded by the accompanying illustration of the City Hall at Cardiff. This imposing building, situated in Cathays Park, is one of the landmarks of the city. The General Purposes Committee of Cardiff City Council recently accepted the offer of the General Electric Co., Ltd., to illuminate it experimentally, with the results shown above. In the illumination of the clock tower, approximately 154 feet high, the energy-expenditure was only 3,000 watts. The lighting was effected by means of a new type of narrow angle flood-light recently designed by the Illuminating Engineering Department of the General Electric Co., Ltd.

The face of the hall calls for different methods. In this case lighting units with an exceptionally wide angle of dispersion were used, the energy-consumption being 4,000 watts. The total energy-expenditure for the entire building was thus 7,000 watts, which is considered economical in view of the uniformity of the illumination. The experiment excited much local interest, large crowds assembling to examine this novel lighting installation.

Brighter Lighting for Summer Resorts

Under this title *Electrical Industries* points out the opportunities for better lighting on the fronts of seaside places during the season. Before the war there was quite a movement towards attractive displays of light in the evening; since then (possibly owing to the effect of "summer time") less effort has been made. Nevertheless the idea is well worth the attention of Parks and Entertainments Committees, and a great deal more might be done to render seaside resorts brighter places, by night as well as by day.

TRADE NOTES & ANNOUNCEMENTS

ILLUMINATED "CREATURES" AT WEMBLEY

In the note in our last issue referring to the new lighting arrangements at Wembley, reference was made to one ingenious novelty—the illuminated animals, birds, etc., that are to embellish the lake and gardens. We have since had an opportunity of witnessing the construction of some of the devices at the workrooms of Mr. Charles Selz, who has undertaken the complete job of preparing this section of the lighting scheme.

We are informed that it is only a month since this matter was settled. Nevertheless remarkable progress in the preparation of the small army of animals and floating devices has already been made. Rows of penguins, owls, water-lilies, parrots, tortoises, frogs, giant snails and other creatures are already manufactured. In another section of the workshop ducks were being tested in a miniature tank, and our attention was drawn to the special floating device, resembling the keel of a boat, with which each is equipped. The swans are amongst the largest creations, but perhaps the giant frogs and fantastic forms of fishes are the greatest oddities. There is also a series of floating Noah's Arks.

Besides birds of brilliant plumage, squirrels in large numbers will be seen in the trees, whilst in the Garden of Eden the forbidden fruit will consist of oranges and lemons as big as footballs. The serpent we saw in an advanced stage of construction; the only creature we cannot recall inspecting is the crocodile, but he, too, we were assured, was well under way.

Enough has been said to show that the lake and gardens at Wembley are destined to become very strange places by night. All these creatures and devices are made up of wire framework covered with specially treated and hand-painted silk, and we were assured that the process to which this is subjected renders the fabric entirely weather-proof. Provision is made in each case for the insertion of sufficient lamps to illuminate the entire object evenly. The distribution of all these illuminated objects certainly constitutes a novel step in exhibition lighting.

SOME NOVEL LIGHTING FITTINGS.

From Messrs. Engineering and Lighting Equipment Co., Ltd., we receive some particulars of the "Glasgow" street lighting fitting. A polar curve illustrates the advantages in light distribution as compared with the bare lamp, and a special feature is the provision of means of lowering away from the case by means of phosphor-bronze toggles, giving easy access to the interior. We understand that this form of unit is proving very popular with municipalities, and that about 350 lanterns have been ordered by the Islington Borough Council. A large nuumber of these fittings have also been installed in connection with improvements in lighting recently effected at the Prince's Dock, Glasgow.

Another attractive series of units available from the same firm is the "Monax" type for office use. These are totally enclosed units, and the diffusing glassware assumes a highly ornamental form. A feature is the softness of the light, and for lighting large offices, public buildings, etc., this class of units has considerable possibilities. They have been adopted by a number of important institutions. It is stated that, notwithstanding the high quality of diffusion, the absorption of light does not exceed 17 per cent.

OSRAM G.E.C. MOTOR-BUS LAMPS.

A leaflet issued by the General Electric Co., Ltd., gives particulars of lamps specially designed to withstand the severe conditions met with in motor-bus traffic. White sprayed lamps are specially recommended when diffusing globes in buses are not used; it must be remembered that lamps in buses are relatively close to the eyes. Hence the importance of screening the filament in some way, and giving a soft and comfortable form of illumination.

We have also to record the receipt of specimens of the G.E.C. "Gecophone" grip terminal. This is specially suitable for wireless work, as it provides a tenacious grip and a terminal attachment without the need of soldering.

THE SHERINGHAM DAYLIGHT.

In the course of a visit to the Sheringham Daylight Development Co. we were recently afforded an opportunity of seeing some of the latest models of these "artificial daylight" units, to which reference was made in the account of the Ideal Home Exhibition in our March issue.

It will be recalled that in these units the alteration of colour necessary to secure resemblance to daylight is effected by reflection of light off an extensive surface, on which is stencilled a pattern consisting mainly of ultramarine, with a small admixture of emerald green and a still smaller proportion of yellow. On the proportions of these three colours the accurate imitation of daylight depends.

In the original design a small proportion of vermilion was used. Now this has been found unnecessary and yellow has been substituted. As a result of this and other advances the reflecting power of the surface is materially improved. But in any case users of artificial daylight should understand that the "efficiency" of such a device is not the most important consideration. A large loss of light in the conversion is inevitable. Accurate imitation of daylight—the provision of an unchanging light suitable for colour-matching is the vital advantage of good artificial daylight—enabling manufacturers of textile materials and dyers to be independent of the vagaries of natural daylight. (We were assured that in rooms devoted to colour-matching in certain mills it has been decided to rely on artificial daylight alone, and the windows have accordingly been darkened.)

Permanency is of course important. A matter of some moment in this, as in any direct lighting unit, is the possible effect of dust on the surface; equally vital is the question of a possible alteration of the colours with time. We were informed, however, that the firm had recently issued a circular to all known users, asking to be informed of any deterioration, and offering to make this good free of charge. This, it is stated, did not lead to a single complaint; the only enquiries received were concerned with recent advances and in a number of cases the latest forms of units were purchased and substituted.

We were rather interested to observe that the price of these units—rather formidable in the case of the first designs!—has been substantially reduced, and to note the tendency towards the use of lamps of high candle-power giving illuminations more closely approaching those available with natural daylight.

CONTRACTS CLOSED.

The following contracts are announced:—

MESSRS. SIEMENS and ENGLISH ELECTRIC LAMP CO., LTD.:

The Admiralty, a large quantity of Siemens gasfilled, standard vacuum and traction lamps for use of H.M. ships.

The Metropolitan Water Board, requirements for standard gasfilled lamps and Silvalux gasfilled lamps (opal bulbs) for a period of twelve months from 1st April, 1925.

Leeds City Tramways, tender for the whole of their requirements for traction lamps for the ensuing year.

THE GENERAL ELECTRIC CO., LTD.:

The Admiralty, contract for 11,450 Osram flashlight lamps and 16,400 Robertson tubular lamps; also large orders for Osram vacuum, gasfilled and squirrel cage traction type lamps.

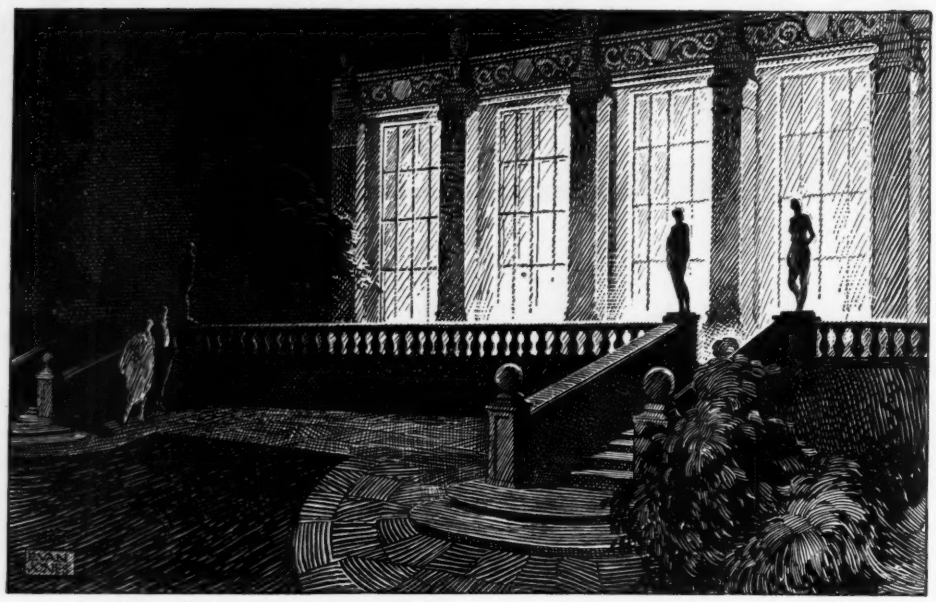
Southern Railway, six months contract for the supply of Osram vacuum and gasfilled lamps and Robertson carbon filament lamps.

L. M. & S. Rly., contract for 2,000 train-lighting lamps.

Port of London Authority, three months contract for supplies of Osram gasfilled lamps.

Metropolitan Water Board, contract for twelve months for supplies of Osram squirrel cage traction type lamps.

Country House Lighting



The above illustration is taken from "Lighting Installations in Town and Country," the illustrated booklet issued by Messrs. Allen-Liversedge, Ltd., to which we referred in our January issue. This is only one of a number of charming pen and ink sketches, and we are reproducing it as an illustration of somewhat novel methods in catalogue literature. Other illustrations in similar style deal with municipal buildings, factories, bungalows, cowsheds, etc.

A NEW TYPE OF KINEMA PROJECTOR.

At the King's Cross Kinema on February 4th, there was a demonstration of a new type of kinema projector, in which a number of improvements have been embodied. Hitherto all living pictures have been projected on the screen by essentially the same method, i.e., by the use of automatic shutters, alternately opening and shutting as the film is moved forward to show a succession of pictures. It is believed that this succession of light and darkness must inevitably be accompanied by some degree of eye-strain. In the new "Arcadia" projector quite a different method is employed. By an ingenious arrangement of rotating mirrors successive pictures are rapidly imposed on the screen, and throughout the process the amount of light falling on the screen is substantially the same. In addition the whole mechanism is so designed as to promote steadiness of the pictures—a quality which is particularly noticeable when wording is shown on the screen. The special method of projection is also stated to give rise to a distinct stereoscopic effect. In addition there are new mechanical features conducive to noiseless and smooth running, and it is claimed that the wear on the film itself is much reduced, so that the life is considerably extended.

ZEISS REFLECTOR LAMPS.

In our January issue we drew attention to the new lighting units being introduced by Messrs. J. W. Atha & Co. By an oversight the note referred to an "upper parabolic metal reflector." We should like to correct this by stating that the reflector is of glass—being in fact a special product of the firm of Zeiss, of European reputation for glass-work. It is contended that the results obtainable with these reflectors could not readily be obtained by using a metal reflector, which, moreover, is not nearly so stable.

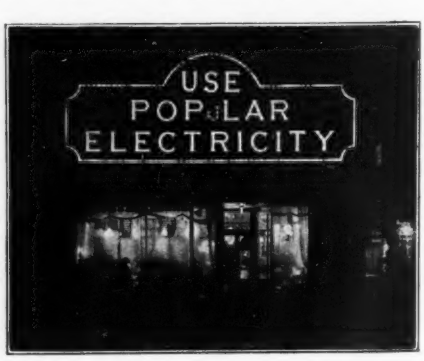
SOUTH METROPOLITAN GAS COMPANY
ANNUAL MEETING

At the ordinary general meeting of the South Metropolitan Gas Company on February 11th Dr. Charles Carpenter, who presided, mentioned that there had been an increase of over 6 per cent. in sales of gas during the past twelve months. He paid a special tribute to the work of the research department, and referred to the efforts that the Company had made to improve the gas appliances supplied. Much care had been devoted to the design of gas burners, which were required to work as independently of atmospheric dust and dirt—to-day one of the serious problems of life in the Metropolis. Dr. Carpenter also recalled the difficult situation that occurred at the outbreak of war, owing to the shutting off of foreign supplies of materials for mantle manufacture. The store of materials which the Company had accumulated enabled them to give aid to the mantle-making industry during a critical period. These stocks had now been replenished and the staff had acquired, for emergency use, a knowledge of the technique of mantle-making. In referring to the great part played by the gas industry, Dr. Carpenter pointed out that electricity could often be generated exceptionally cheaply by the aid of gas engines; he mentioned several large works run in this way, where the electricity generated was sufficient to supply a town of moderate size.

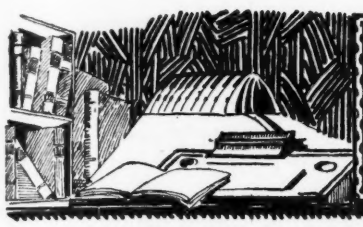
After pointing out the close relation between the coal supply and gas manufacture, Dr. Carpenter referred to the very satisfactory results obtained from the system of copartnership initiated by the South Metropolitan Gas Company many years ago. He suggested that in the adoption of copartnership lay the most hopeful solution of many industrial problems, including the reconciliation of the claims of employers and workers in the coal-mining industry.

ADVERTISING ELECTRICITY.

The accompanying illustration, reproduced from the *Osram Bulletin,* shows the electric sign over the Poplar Electricity Showrooms. This sign is operated by motor-driven flashers.



The words "Use Poplar Electricity" appear at periodic intervals. After these words have appeared for a few moments the letter "U" is flashed between the "P" and "L," thus converting the word into "Popular." The border consists of Osram colour-sprayed lamps in red, blue, orange, green and white. The letters in the sign are made up of clear gasfilled lamps, and the "U" is formed of six red colour-sprayed lamps.



REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

SAFETY FIRST (*Official journal of the National "Safety First" Movement, published at the Head Offices of the Association, 119, Victoria Street, London, Vol. 1, No. 1, April,* 1925).

We have before us the first issue of "Safety First," the official journal of the National Safety First Association. A foreword by the Home Secretary, Sir William Joynson-Hicks (President for 1925), a letter from the Duke of York to the London Council, and a message from Rear-Admiral Sims, of the United States Navy, are reproduced to illustrate the influential support which the movement receives.

The industrial side of the movement is dealt with in articles by Sir Thomas Legge (Senior Medical Officer, Home Office), and in "Why Accidents Happen," by the Association's Safety Engineer. There is a summary of a lecture by Mr. A. L. G. Whyte on safety first methods in a large soap works, and a contribution by Professor W. H. McMillan on "Safety First in Mining"; and there are many readable notes bearing on the safety of street traffic. Some tabulated data reveal the really appalling numbers of persons killed and injured in the streets of London, and the urgent need for the work of the Association in this field.

But the journal has also its lighter side, which shows how well, by the aid of the services of the skilled journalist, the aims of a serious movement can be effectively illustrated in a popular way. There are many attractive "news" photographs. Perhaps one of the most happy of these is the picture of the police-officer giving safety first lessons to children in elementary schools. There are also some reproductions and sketches from an amusing booklet, issued twenty years ago, and apparently designed to show that other methods of locomotion besides the railway are not unattended by danger.

The first issue of the journal is a creditable production, aptly illustrating the very varied activities of the N.S.F.A. and the scope of its work—conducted with very moderate financial assistance. To readers of our journal the methods are of interest in illustrating popular methods of treatment such as we, in the illuminating engineering movement, need; and we gladly recognize that in the safety first movement the importance attached by the Association to proper lighting, both in streets and factories, is an indispensable element in security.

We have also to record the receipt of several interesting books, which will be reviewed shortly. "Illuminating Engineering," by F. E. Cady and H. B. Dates, is a text book for students issued in the United States, and contains a series of contributions by specialists on the chief illuminants and aspects of lighting. "School Vision" is a readable book by Dr. James Kerr, well known to our readers as a member of the Council of the Illuminating Engineering Society, and contains a section emphasizing the hygienic importance of good illumination.

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Lays on Illumination

IV.—THE LAMP.

WHEN in the Lecture-room I'm placed,
My brothers round me (incorrectly spaced!),
I hear them talk of "good illumination,"
And listen to one-sided explanation.
One says the Lighting Industry is "It."
Another talks of Public Benefit,
They never seem to think of *me* a bit!

Up in the Office every night
I hear complaints about "the wretched light."
It's not *my* fault—and yet I feel ashamed.
I really cannot see why *I* am blamed.
They ought to go for Messrs. —— (unnamed!).

When in the Public Thoroughfare I try
To shed my light on all the passers-by
They glance at me, then quickly look away.
Well, hang it all!—dash it!—I mean to say!
It isn't complimentary, anyway.

Though in the Drawing-room I love to shine,
Is it by accident or by design,
When everybody else is gaily dressed,
I get no shade?—my feelings may be guessed!
When I have thus unwillingly transgressed.

When on the landing, near the Bathroom door,
I hear the water flowing. I feel sore.
They go on washing for an endless time,
But no one comes to cleanse *my* coat of grime.
Yet they complain my light is under par.
It only shows how selfish people are!

With my gas neighbour, just across the street
I often chat. Although we cannot meet,
Our rays, by intermingling, can converse.
His lot is quite as bad as mine—p'raps worse.
Though we are rivals, we can both agree
In emphasizing human frailty.

I tell him how diminishing P.D.
Affects my output prejudicially.
His insufficient piping, he will mention,
Is urgently in need of due attention.
(We both are censured, I need hardly say,
For loss of light arising in this way.)

When in the Railway Train or Bus,
Is it fair usage for the worst of us
To run, year after year, till we expire?
If one *is* merely glowing wire
Isn't there *some* time when one may retire?